BUILD
YOUR OWN HOME

: BY :

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RESIDENTIAL BUILDINGS SUITED TO INDIA.

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CHEAP & HEALTHY HOMES FOR THE MIDDLE CLASSES.

DISPOSAL OF DOMESTIC SEWAGE, Etc., Etc.

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PREFACE

It was announced more than seven years ago that an English translation of *Sulabha Vastu Shastra* was going to be published. As a matter of fact a translation of the original Marathi treatise was made by a professional friend. **Mr. S. K. Deo,** B.E., Supervisor, Bombay P. W. D. in 1935. But its publication had to be shelved *sine die*, because, I had in view the object of studying the problem of contemporary building practice in the civilised countries of the world; And did actually proceed on a tour round the world in the following year; And as the publication had been already delayed I considered it immaterial to delay it further as I could include in the book, whatever new ideas I could gather abroad, which could be suitably adapted to Indian conditions. Again, on my return the scanty spare time at my disposal was pre-occupied with urgent work, relative to other publications. But far more important than these reasons, was the revolutionary change in the entire technique of Building Construction and Architecture that had come into being during all these years on account of very extensive use of new materials like reinforced concrete. As a result of this change the translation already made of my book which incorporated the older methods, seemed to me, to be totally inadequate or unsuitable. Hence it had to be entirely overhauled and re-written by myself this time. Thus, although the main trend of the original book has been consistently adhered to, yet so much new matter has been included, that to all appearances, the book will be found to be entirely different from the Marathi and other treatises, of which it was proposed to be a translation.

An attempt has been made to enhance the utility of the present volume by adding special chapters on (*a*) Quake-proof buildings, (*b*) Homes and A. R. P., (*c*) The rates of labour involved in getting various jobs, connected with building

construction, done, etc. It is hoped that the latter in particular, will be appreciated.

In my humble way, I feel confident about the success of this English version. The original book has proved its utility in the several regional languages by enjoying a wide circulation in different provinces in India. The present volume has the added advantage of being revised, enlarged and brought up-to-date. I daresay, this is the first venture in India for a book of this type for Indian conditions,—may be, even the first venture of its kind in the wider English-speaking world—in putting all the facts concerning building a house, in one volume so as to guide a layman in building his own home; beginning with advising him on the financial aspect and selection of site, and then taking him through all the stages of erection, from the foundations, in sequential order, to the roof and finishing. Of course, there are a number of excellent text-books on the subject, but they presume a technical knowledge or back-ground on the part of the reader, and hence, are not in a form to be comprehended by laymen. Nor are they likely to make an interesting reading.

In conclusion, I whole-heartedly thank all those who have directly or indirectly helped me in the compilation of this book—amongst them, Mr. Deo whose name I have already mentioned above in connection with the original English translation.

Unfortunately the book is being published at a time when paper and all the printing materials are available in insufficient quantities and with great difficulty, at a very high cost. I preferred, however, not to delay the publication any longer and have tried to offer the book to the public at reasonable price under the present circumstances.

Poona. R. S. D.

1*st January*. 1948

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INTRODUCTION

The urge to own a house may have started from various circumstances—some may have thought of it when a lucky family of one of their friends proudly moved into a new lovely cottage which they whole-heartedly envied, some may have been prompted by the thought that thousands of their rupees which had already slipped away in the form of rent through so many years could have brought them a home of their own. Other people, rather fastidious and always in quest of ultra-modern conveniences, may have been discontented with the antiquated designs and equipment in every house they hired; some others may have been worried by the constant sickness visiting their families attributable to the insanitary conditions of the houses occupied by them and so on. That urge may come—however, when it does come it cannot be trifled with. It gradually gains in strength and makes your mind more and more uneasy until you make up your mind once for all to satisfy it either by buying or building a house just as the urge for marriage which can only be satisfied by marrying.

In this way, when once you decide to own a house, the problem before you is, what sort of a house it should be. The first thought that flashes in your mind is about its architectural beauty. What will my house look like is the first question you usually ask yourself. Some buy a house because they are enchanted by its external appearance, some are attracted by certain special features such as a circular window, a spacious drawing hall, an extensive terraced roof commanding a good view of the landscape, while there are others who are enamoured of certain gadgets provided in it such as balconies, mirrored cabinets, built-in furniture, etc. Those who are not satisfied with buying a ready-made house but want to build one to order are in no way better informed in respect of the real requirements of a home. Their dream perhaps started with a pretty picture of a beautiful villa in some magazine

and they wish to copy its features. Or they saw a newly built attractive home of one of their friends and want to produce its prototype. If they, however, follow up their wish, they are sure to regret their action. For, not only do the living habits, traditions, family composition and financial position of one family differ from those of another, but so also do the shape, size, situation and aspect, etc. of the former building site from those of the latter and these must demand quite separate individual treatment. *A home must fit a family as clothes do the wearer.*

The value of a house should depend not upon how it looks, but upon how it works and functions. For, "handsome is that handsome does". The modern way is to design *from inside out* instead of *from the outside in* as in the days of old. That is, "Design the inside arrangements first for maximum comfort and health and the external appearance will take care of itself" is the present motto. It is possible to give a pleasing appearance in a variety of ways. Modern architecture is thus based on 'functionalism'. Every part of a house must be so designed that it best fulfils its function or the purpose, for which it is intended, and that it expresses honestly what it is inside—no camouflage, no masquerading for what it is not, is allowed. Beauty is to be judged from the standards of utility and honesty and not from those of elaborate ornamentation. Thus the most important thing in a building is its planning—it is the soul of the house. Next to it come its construction and architecture which are, so to say, like the body and superficial dress. A neat dress is essential to reflect one's personality, particularly in the case of a home which is the pride and stake of the family, but if the home is planned to suit the family's needs, beauty will come in automatically, if materials of the proper type are selected and properly disposed, and a little attention is paid to the relative proportions of the parts exposed on the outside. If

the inner 'soul' is good and the 'body' well-built and healthy, any dress worn will set it off. No special effort is necessary for the porpose; for, beauty and utility are inseparable in good architecture.

However, no attempt has been made to treat either the subject of planning or that of architecture in this volume; for, that is already done in great detail in the author's "Modern Ideal Homes for India". It is only the aspect of construction that is sought to be dealt with here.

The first attempt in this direction was made about 15 years ago when I was engaged in promoting the Saraswat Brahmin Co-operative Housing Society, Poona, of which I was one of the founders. Not only the entire landscaping and planning including the layout of roads and drains etc., but also the construction was entrusted to me. It was there that I acquired the first hand knowledge of the real difficulties a layman is faced with. I found that the average house-builder did not even know his own requirements of accommodation—much less how the house should be planned, what it would cost, what materials were to be employed and how the construction should be executed. I very much deplored that state of affairs and resolved to do my bit by publishing detailed notes on construction right from the collection of materials, foundations etc., to the finishing of the roof in a popular, easily understandable style in the regional language so that even the mistries, karkoons and artisans who are real builders should know it and consequently I compiled a treatise in a very simple style in English on planning, accompanied by a number of illustrations of well-designed homes of varying sizes and costs. The former immediately took shape and appeared in the form of a book "Sulabha Vastu Shastra" or "Building Construction Simplified", first in my own mother tongue *viz.* Marathi. This was so warmly received by the public that I was encouraged to bring out its reprint within a few months

and later on to publish its translations into Gujarati and Hindi. It was also in demand in other languages as well, particularly in Bengali and Kannad; but experience by this time proved that a translation into English would reach more people and cause less bother and expense than publishing different editions in so many regional languages of India Accordingly, a translation was prepared by a professional friend: but I had to shelve it as I was engaged in compiling the second book mentioned above and consequently found very little spare time to do all the work in connection with it, in the midst of the very busy life of a full time responsible government servant in the Public Works Department—an atmosphere hardly conducive to literary work. Just about this time, I took an opportunity of travelling round the world for studying building practices and modern architectural trends in most of the civilized countries in both the hemispheres, and in view of the fresh experience gained, I found, upon my return, that the translation already made fell very short of my new ideas of what the book should be. I thought it was necessary to recast the whole thing before it was presented to the public. Thus, the present volume though essentially based on the general theme of the original treatise, contains much more and is treated in quite a different manner.

I carried out my second idea by publishing "Residential Buildings Suited to India," in 1930. When that was sold out I published an entirely new book, "Modern Ideal Homes for India" instead of coming out with a revised edition which seemed to become almost out of date in the light of fresh knowledge gained by me in the course of my world tour as also in view of the change that had crept in recently in the field of architecture as a result of the advent of new materials such as reinforced concrete.

I have casually come to learn that my book has come in for criticism at the hands of certain people with vested

interests particularly in the contracting line. From what I gather the charge made against the book seems to be one of divulging professional secrets—which has emboldened the house builder to check and challenge the statements either in respect of the methods or cost of construction on the authority of these books. If that be true, I take it as a compliment to myself and rejoice in it. As a matter of fact it was my purpose in compiling these books that an average lay home-builder should take live interest and acquire insight into the so-called 'mysteries' of construction. It has really gratified me that no less than 10,000 copies of the treatise in various regional languages have so far been in circulation in several provinces, illuminating the path of a very large number of people so far groping in the darkness.

I have always advocated that it is the best policy to hire the services of an architect, even at the sacrifice of certain luxury-items which his fees would otherwise have provided. His extra cost is a guarantee of comforts, soundness of design, of good taste, as also a mark of distinction. It is a sort of insurance for getting your money's worth, just as the correct diagnosis at the very outset at the hands of a competent doctor. If people study this book before they go to an architect, better co-operation would be ensured and the result would be a design which would prove of very great advantage to themselves and a credit both to them and the architect.

However, it is not only in this country but also in a civilized country like America that people look upon an architect as an expensive luxury and this seems to be very common, because, according to the statistics of the U. S. A. Department of Labour, 80 per cent. of the houses in America are built without the benefit of a specially engaged architect. A large number of the people design and build their own homes and a few buy stock plans designed by architects. Hence, the reader need not feel discouraged if he cannot afford an architect. It is

possible for an intelligent and *cautious* person to plan and also to construct an excellent home provided he or she cares to learn a few fundamental facts. As a matter of fact, it is not necessary to master the technique in details such as the stresses in a beam or a floor etc. The science of building, so far as ordinary residential structures are concerned, is no more mysterious than, say, the game of contract bridge.

It is the purpose of this book to guide the layman at every step—from financing the scheme, selection of materials, through every stage of building upto the finishing of the roof and plumbing. Both the pros and cons of every alternative are discussed and the various methods of construction are described without bias. Building practice is bound to differ in a vast country like India, according to the variations in climate and materials and also social habits. Still, a fairly representative picture is sought to be drawn here. Though the writer is in favour of the modern trends in architecture, he has mentioned plain facts which are applicable to any style of architecture.

Building one's own house is a game full of great fun provided you undertake it in a real spirit of sport to enjoy a certain amount of thrill it contains and not to fret and get nervous if the slightest mishap were to pop up. You will enjoy it the more if you endeavour to understand a little more of the art of construction. In designing and planning or building a house you transmute your cherished desires into concrete realities. What a real pleasure it would then be to watch a building rise from the foundations slowly through all its stages to the roof. Moreover, unlike a picture hung up on a wall or a statue installed on a pedestal,—which give pleasure only to the eyes—the finished product of a building is a livable thing giving comfort and happiness not only to you and to your family but also to the generations to come.

These pleasures are not in store for those who live in rented houses all their lives. Nor are the thrill and adventure

contained in it for those who get their houses built by others.

However, all these pleasures are, not only lost, but on the contrary, a house becomes a curse to those who spend more than they can afford, and thus have to struggle hard to face the day of payment. This has been so common that it has given rise to the well-known adage that "Fools build houses and wise men rent them." But a little reflection will show the fallacy of it. The fault does not lie with the system but with the men themselves, who proceed in an unbusiness-like manner. They not only do not care to draw a plan and frame an estimate but very often the work is undertaken without even an idea of their own capacity to spend, and in many cases without the necessary funds, both as ready cash in hand and sums due to come in. When the actual work is started, unfortunately other circumstances also become more unfavourable. For instance, during the time the work is in progress, the owner rises into great importance as if he is the king of a small domain. People from the humblest coolie or carpenter and mistry to the architect or salesman of building products, all flatter him and try to pamper his whims and seem to show respect to his idiosyncrasies. They are all interested in suggesting to him attractive but costlier methods and materials; but under the intoxication of a vain glory he does not realise it. Even well-meaning friends voluntarily shower suggestions to which he gives effect. To add to the evil, unfortunately, some of these suggestions come very late, and to carry them out part of the work already constructed has to be dismantled, and so on. The result is obvious. It is no surprise if the owner goes into bankruptcy and in extreme cases the property falls into the hands of creditors.

That is why, I have said above, that only an intelligent and *cautious* man should attempt to build. If he succeeds, he alone will experience the indescribable pleasure and satis-

faction of home ownership—a pleasure which cannot be calculated in rupees, annas and pies. Besides, house property gives the owner and his children social stability, security, and even certain protection against bad times He can temporarily mortgage it, or rent part of it and earn some income to tide over the difficulty. A house is called a 'frozen asset' i.e., one which cannot be easily frittered away and therein lies its importance. Compared to this, investments into stocks and bonds, on the other hand, are 'fluid', I should say, rather volatile assets, and may soon evaporate because you can easily gamble them away, apart from the drops and fluctuations in their prices.

With this rather long introduction, for which an apology is scarcely required, we shall proceed to discuss further topics in a builder's venture.

WHAT HOUSE SHALL WE GO IN FOR?

The old, the recently built or a new one?

Before finally deciding to build our own house we shall consider the prospects of buying one ready-built. The latter may be either a house built, say, 50 or more years ago, or one recently built and occupied, by some family or altogether a brand new house built for sale. Let us consider the old house first.

The main advantage of such old houses is their cheapness. Area for area, they may be twice as cheap as recently built houses. Another advantage they possess is their spaciousness. There will usually be a large number of rooms and spacious halls though interspersed by a number of columns or posts because, in those days they used timber beams and these naturally were rather limited in length.

A third advantage is the substantial construction of these houses. Both labour and material were cheap in those good old times, and further, there was a necessity of building for safety; hence massive construction was generally adopted.

Against these advantages may be set the following disadvantages. The first and foremost is that from our present standard of light and air an old house will be found to be quite unsuitable. The advantage of spaciousness is also doubtful in these days when servants are rather luxury than necessaries. We want compact and convenient houses in these days.

It may be argued that if they be initially so cheap, why not buy and modernise them by spending a part of the saving? But an old house may in all probability be very old and worn out. Though outwardly of substantial construction, under the surface it may usually betray a number of defects caused by age. For instance, the ends of beams or posts hidden in walls may have disintegrated; timbers of the roof may have

rotten inside the coat of paint; drains may have got choked up and so on. If such buildings are left undisturbed they give a long carefree service. but if you scratch them with a view to alter or renovate them, a major operation may usually be required and the latter proves both a ticklish and expensive job. All these considerations altogether go against the purchase of such houses.

Let us now consider what attractions are offered by recently built houses, built more or less on modern lines and occupied by a family for a few years. In the first place in 99 cases out of 100 such houses will not suit the purchaser in respect of location, design, size, arrangements and equipment etc, and its price also must be within his reach. This is next to impossible. The purchaser has, therefore, to sacrifice many of his cherished desires and make a compromise. It is like buying a ready-made suit of clothes, but, a compromise can be made in the case of a suit as it lasts only for a year or two But a house is expected to last for generations and it is simply ridiculous to make a compromise all through the life of the purchaser and also to force his children and grandchildren to do the same.

However, if you are so lucky in getting that one chance out of a hundred and the sacrifice you have to make is very small and negligible, there would be certain advantages. Building a new house means a lot of mental worry. Negotiations for the building plot, including legal formalities, surveys. fixing boundaries, planning, dealing with contractors, waiting patiently for months together till the new structure comes into existence out of chaos—all this is saved: secondly, there are so many unknown factors in building a new house that, the experiment may prove very expensive and involve you into new risks.

Still, there is one important point which might outweigh all advantages. If such a really good house is offered for an

attractive price, and if it was really built or purchased by the family and occupied by them for a few years why are they selling it now ? If they are doing it because the head of the family was transferred to some other place or they are building a new and a bigger one elsewhere to meet the growing requirements of their family, it is well and good ; there is nothing to suspect. But often times such houses are sold because some superstition or another attaches itself to it. The financial position of the bread-winner may have run down ever since he came to live into it and he was forced to sell it. May be, several successive deaths may have occurred there after occupying it. Some such instance might account for the decision to get rid of the house. The house may really have nothing to do with such occurrences. It is possible that if you acquire it your experience might prove to be just the opposite. But human nature is frail and a house is such a thing with which many superstitions either good or bad get associated particularly in the mind of ladies who are by nature credulous and emotional. They may not express their feelings, but the effect on their sub-conscious minds is sure to lurk. Hence, it is necessary to make thorough enquiries about the previous history of the house particularly the reason of its being put on the market.

Then, if you rule out buying a recently built occupied house, the only choice left is that of buying one newly built specially for sale. Such houses are built by speculative builders, who are very shrewd people and build such houses as appeal to the popular taste and fancy though at a cheap cost. Still, they may not exactly suit your requirements and you have again to make up your mind for a compromise.

Further, since they are built with the specific object of making profits, one should look upon their construction with misgivings in respect of soundness, unless they are built by large firms dealing in land development and real estate on a

large scale and thus have a considerable reputation at stake. Otherwise, one does not know whether the material hidden behind the attractive paint is new or old and disintegrated. Even if you get a guarantee it probably covers too short a period to betray the inherent defects of the structure.

Then again, if yourself think that you have not to pay the architect or the surveyor etc., their fees, someone has already paid them and they must certainly have been included in the price of the house. The latter includes all such items as the price of the land plus the profit on it, interest on capital from the time the land was purchased to the date of sale, advertisement charges, sales commission etc. etc. Some of these items you would never think of if you were to build your own house. All these items may amount to 25 per cent. of the sale price. If the construction is sound this is fair and reasonable because the builder has to run great risks and undergo much trouble.

From all these considerations, buying a brand new house though offered for an attractive price is not a simple proposition as it apparently seems to be. Should you really think of buying either a secondhand or a new ready-made house, what to look for in it for soundness, is given in a special chapter at the end of the book.

Then again you will be faced with the question as to whether the house you want to build should be a flat, i.e., consisting of two or more tenements, or one suitable for a single family.

Although by far the greater part of our people live in houses suitable for a single family, of late years there has been an enormous increase in apartment buildings. This is mostly due to economic conditions. Some people build larger houses than necessary for their immediate requirements and rent out part of it either to their relations or friends. This is doubly advantageous to them; one, that they earn some monthly income and two, that both the families derive mutually the

advantage of social contact. Again, when the family grows the part which is rented out may be required by it for occupation.

However, there are certain disadvantages also. The principal one is noise. It is difficult to prevent the sounds of wireless, footsteps and vibrations arising from walking of people from one flat to another, also the noise made by boisterous children of the neighbours, particularly when you want a peaceful and quiet atmosphere. Secondly, your efforts at making a good garden are sure to be frustrated. You may love flowers and wish to grow them plentifully in front of your house but you will soon be disappointed to find them plucked carelessly away and that it is an unpleasant task to trace the culprits. Thirdly, you cannot maintain the premises scrupulously clean as you wish them to be. Your neighbour's children may not have been trained to it and the servants are bound to misuse them. Fourthly, the flat possesses another psychological defect. The flat dweller, whether he is the owner or a tenant, cannot stroll out or sit in open air on the lawn. He misses the restful vision of the green lawns and flowers outside the windows and generally feels that his privacy is restricted.

HOW MUCH CAN I OR SHOULD I SPEND ?

The man who builds and wants wherewith to pay,
Provides a home from which to run away.

—*Dr. Edward Young.*

So far we discussed the various ways of owning a house. This we did in the abstract. It is now time to think about it from a practical point of view, involving ourselves into the question of finance, which, as the couplet of Dr. Young quoted above shows, is the crux of the whole thing. If it is not satisfactorily tackled, ours will be simply building castles in the air. The entire success of our venture will depend upon it and the extent to which we successfully solve the problem will be the test of our cleverness or capability of undertaking the venture.

There are three different aspects of the main question: How much can I or should I spend, *viz.*, (*a*) If I have not got sufficient money of my own, would it be wise to borrow the deficit ? And if so, to what extent or what percentage of the total cost ? (*b*) Whom should I borrow from and under what conditions and (*c*) Supposing my requirements cannot be met even after borrowing a loan to the permissible extent, which I can repay within a reasonable period, what ways and means of economy should I adopt in order to balance my budget ?

The first aspect is discussed in this chapter and the two remaining in the next two that follow.

Before, however, we proceed to the discussion of the actual problem I propose to give a few ' don'ts ' to prepare the ground for our discussion. They are rather like the ten commandments for the prospective house-builder to obey for his ultimate good.

1. **Don't over-buy a house.**—A house which you cannot afford will scarcely be that home which is calculated to give

you peace of mind and happiness. Not only does it become a constant source of worries but it forces you to sacrifice several other equally valuable things in life.

2. **Don't count chickens before they are hatched.**—If you borrow a large sum of money in the expectation that you will be able to save much more than you have so far been doing, to repay the loan, my advice is "Wait, save first, and buy or build afterwards with a lump sum so saved."

3. **Don't buy or build.**—At least postpone the idea for a few years under the following circumstances; otherwise you will come to grief:

(*a*) If your services are likely to be transferred or your business is likely to require you to move away from the place in-the-not-very distant future;

(*b*) If the money you wish to spend on a house is likely to be demanded by more urgent or obligatory purpose, e.g., your daughter's marriage, boy's or girl's college education, your son shortly opening a medical clinic, etc. etc.

(*c*) If you do not see your way to repay the loan, you have to borrow, within a maximum period of say 20 years.

4. **Don't spend every pie saved on your house.**—You must reserve some amount to provide for the rainy day. For, illness or some unforeseen contingency may require some hard cash. This reserve should be a minimum of three months' income.

5. **Don't raise a loan on the mortgage of your insurance policy,** to pay for the house, unless a combined policy for life assurance and house-building is purchased through an Insurance Company.

6. **Don't buy or build a house in the expectation of selling it for profit during the boom period you expect**

to come.—This is gambling, pure and simple, when the odds are definitely against you. The boom period may never come while the value of your house is sure to depreciate through at least normal wear and tear and due to obsoleteness. That is to say, when popular tastes change with the advent of new materials equipments and inventions in the market, a house is sure to get antiquated and thus lose in value.

7 **Don't assume that your income is going to rise and don't base your borrowings on that consideration** even if the income be of the nature of a salary from permanent service in Government Departments on a time scale Let that chance come as a pleasant surprise to lighten your burden and give you joy. For, there are efficiency bars to cross; circumstances quite beyond your control may arise and the so called 'sure' increments may be withheld Again, as the family grows the expenditure also grows, with increase in salary you have to maintain your enhanced status in society. Besides, there are such contingencies as sickness etc., in the family.

8 **Don't tie yourself down for a period of 15 or 20 years denying yourself any luxury just for paying the instalments of top-heavy loans raised.**—Even if you resolve not to spend any further on luxuries, yet, after 2 or 3 years. the frail human nature in you will tempt you to eat the forbidden fruit. You might wish to buy a wireless set or a baby car or the like.

9. **Don't think of buying or building a house unless you have a minimum of 30 per cent. of its cost as cash in hand as your own.**

10. **Don't borrow on mortgage, a loan, the annuities of which extend over a period, before the end of which, your income is likely to be reduced,** e g, if you are forty now and are in service, you superannuate after 15 years, when you retire, and your income is reduced to half, you should in

this case choose a maximum period of 15 years for the repayment of your loan.

To proceed with our discussion now—to pay the full cost of the house in cash is the best policy. It is most economical and at the same time does not involve you into any further responsibility for the future.

But if you have not got enough of cash on hand, there is no risk in borrowing a loan to meet the deficit if it is done *cautiously* as set forth here further on. However, to what extent it is uneconomical will be seen from the fact that for Rs. 10,000/- borrowed now at 5¼ per cent. per annum, you have to pay Rs. 16,000/- in the form of annuities spread over twenty years. Hence, the greater the amount of cash at your disposal the cheaper it is in the long run.

There are three ways of finding out how much money you should safely invest in your house. The first is rough, but one, on which best authorities in Europe and America are agreed, as giving correct results. According to it, you should not spend more than two to three times your net annual income. Suppose your annual income is Rs. 3,000/-. You may spend between Rs. 6,000/- and Rs. 9,000/-. Whether to adopt the lower or the upper limit will depend upon what cash you have on hand over and above 30 per cent. of the total expenditure. This includes the cost of the building plot also. If you have already purchased the plot out of your savings, then you can spend the full amount as above entirely on the structure.

The second way of calculating the amount is very common in America and is recommended by the Federal Housing Association. It takes into account both your income and expenditure and so, is more reliable. For this, it is necessary to find out first, the saving which you are able to make *at present*. Calculate the average saving of the past one year or two. Add to this the amount which you actually pay as rent. The sum

of these is the amount which you can easily pay towards the redemption of the debt.

After this, decide on the period of years, over which you want to spread your instalments, from 10 to 20 years. Ascertain the rate of interest at which the loan is obtainable from banks, insurance companies or other lending bodies. It will usually be between 5 per cent. and 6 per cent. Then find out a value in the subjoined table of interest under the column of the period which you have decided.

Rate of interest	Period of years of mortgage					
	10 years	12 years	14 years	16 years	18 years	20 years
5%	5 64	6 21	6 69	7 10	7 46	7 70
5½%	5 55	6 09	6 38	6 95	7 25	7 54
6%	5 46	5 96	6 42	6 80	7 10	7 35

Multiply this value by the above figure of your saving *plus* rent per year. The result you get is the amount you can borrow safely as a loan.

Add to this the cash you have already saved (which should be at least 30 per cent. of the above loan) The total is the amount you can invest in your house and plot taken together.

As it is assumed here that your income will remain the same as at present during the next 15 or 20 years, and further, that you will spend as much as and not more than you have now been doing, there is a considerable margin of safety, because your income is sure to rise and also you will try to save more by curtailing your expenditure.

Perhaps a concrete example will make this more clear.

Let us assume that Mr. X.Y.Z. draws a monthly salary of Rs. 250/-, that he pays Rs. 25/- per mensem for house rent and that his accounts show that his average savings for the past

12 months are Rs. 40/- per mensem. Further that he has saved Rs. 2,500/- for his house and that he being just 35 now can afford to pay regular instalments to repay his loan for twenty years. Yet, that he wants to do it in 18 years only. Let us also assume that the current rate of interest is 5½ per cent.

Here, his savings are Rs. 40/- and house rent Rs. 25/- per mensem total Rs. 65/- per mensem; or for one year 12×65 =Rs. 780/-. From the above table the value at 5 per cent under 18 years is 7.25.

Therefore, 780×7.25=Rs. 5,655/-. This is the amount Mr. X.Y.Z. can safely borrow because his savings which are Rs. 2,500/- are more than 30 per cent. of Rs. 5,655/-. Adding this amount we get Rs. 8,155/-, say Rs. 8,000/-. He can spend Rs. 8,000/- on the house and the building plot.

If he succeeds in saving more and if his income also rises, he will be able to repay his loan much earlier than 18 years.

By the first method, 2 to 3 times his annual income which is Rs. 3,000/- amounts to Rs. 6,000/- to Rs. 9,000/-. As he has saved a good deal he can adopt the upper limit. Thus it will be seen that the figure of Rs. 8,000/- obtained by the second method is safe.

The 3rd method is more direct and thorough.

First, find out the total available resources. These are (1) cash in hand and the bank balance, (2) long term fixed deposits, bonds, postal cash certificates, (present value only,) (3) securities including debentures (present value only,) (4) other sources such as gold or jewellery which can be converted into cash *with the voluntary, willing consent* of the party or parties concerned, at their present market vlaue. The sum of these represents cash in hand.

Deduct from this the rainy day fund, (minimum 3 months' income).

Next, calculate the total amount you will be able to pay per month to meet the monthly instalment of repayment of loan including interest This will be the sum as in the above example of your present yearly saving and your present house rent (monthly rent × 12).

Deduct from this the following obligatory charges —

(*a*) Maintenance and upkeep of your house. During the first 2 years probably nothing will be required, in the next three years about ½ per cent. of the total cost of the house may be required for renewing paint, colour, wash turning tiles or repairs to roof, repairs to the plumbing system etc. and after the first 5 years full 1 per cent. may be required annually during the period of mortgage.

(*b*) Taxes. These are house tax, conservancy or land tax etc. The house tax varies from 3 to 18 per cent. Other taxes also vary. Local enquiries may be made about them.

(*c*) Premium on insurance of the house against damage or destruction by fire, storm, earthquake etc, about ½ per cent. This is necessary, since you are running some financial risk. The lending agency (of course if you borrow money) will invariably make it compulsory for you to do so.

When the deduction for the above obligatory charges is made it will leave you certain balance for repayment of the loan Find out against this figure of annuity and under that of the term you need for repayment, the amount you can raise in the form of a loan at the current rate of interest from the following table of annuities :—

Table of annuities per month per 1,000

Rate of interest	Period of mortgage					
	10 years	12 years	14 years	16 years	18 years	20 years
5%	10 13	9 7	8. 7	7 15	7 2	6 11
5½%	11 3	9 13	8 13	8 2	7 10	7 2
6%	11 10	10. 5	9 4	8. 8	7.15	7 11

Add to the figure of loan thus arrived at, the saving which you have made, and you get the figure which you can spend in buying a plot and building a house on it.

However, you cannot spend this amount in full. A certain sum has to be reserved for the following items :—

(1) The unforeseen circumstances such as deeper or worse foundations than you first expected, sudden rise in prices of certain materials in the market, omission of a certain seemingly unimportant item in the estimate etc. etc. An allowance of 5 per cent. of the total estimated cost of the house is usually made for such contingencies in the estimate.

(2) A small fee for getting a plan drawn and an estimate framed by one who has plenty of small home building experience to his credit, if you cannot afford the full fees of an architect to guide you from the selection of the plot to the completion of the building including supervision of construction. This may cost you at the most ½ to 1 per cent. of the cost of the building.

(3) Equipment such as curtains, electric fittings, draperies, awnings, rugs, furniture, table-cloths, etc. These you will need immediately after occupying the new house. Provision for the cost of these has to be made forthwith.

(4) Cost of moving your possessions from the present rented house to the new one, cleaning inside, clearing the compound, planting trees and shrubs, gravelling footpaths in short, the cost of getting well settled in the new house.

(5) Cost of certain conventional ceremonies at the start. Personally you may not be keen on observing them, but firstly, you do not want to break the traditions handed down from very old times, and secondly, you do not also want to displease the workmen for the sake of a small amount. For, if it is not done, they (being uneducated and therefore superstitious people) lose enthusiasm in their work.

These are usually —

(a) *Site worship ceremony.* (*Vastu-Pooja*) —Just before starting the work of excavating foundations *Pooja is* offered to the ground in the south east corner of the building, a cocoanut is broken and its kernel together with sweets is distributed to the gathering The *Dakshina*, usually Re. 0-8-3, offered, is received by the *moocadam* (foreman) of the excavators

(b) *Corner stone laying ceremony* :—If the building is costly and is an important structure, some times a few coins and a daily newspaper of that day are put into a bottle which is then hermitacally sealed and buried near the corner (south-east as before) Then a well-dressed corner stone is "well and truly laid" either by the owner who does it after taking a bath or by some distinguished person *Pooja* is offered to the corner stone which is supposed to embody the Griha Devata ; cocoanut and sweets are distributed and dakshina of Rs. 1-4-0 is offered, this time, to the foreman mason.

(c) *Ridge-laying ceremony* :—The ridge which is the highest member of the structure of the house is laid and immediately the foreman carpenter ties together a beetle nut, a piece of dry turmeric and copper coin wrapped up in a piece of sacred cloth. *Pooja* is offered to the ridge, cocoanut and sweets are distributed and it is now the turn of the foreman carpenter to have the honour of receiving dakshina (Rs. 1-4-0) and the sacred cloth.

(d) The last is the *Vastu-Shanti* ceremony amongst the Hindus—this time for the feelings and satisfaction of the owner This is done with greater or less pomp according to the social status of the owner. A small image either of gold or five metals (Pancha-dhatu-

rasa) is worshipped, *Havana* is made (sacrificial fire is kindled and ghee and rice are offered amidst chanting of sacred mantras) and all the workmen right down from the excavators to the mason and carpenter and mistry are invited to dinner. The architect and contractor, if any engaged, and their staff, and friends and relations of the owner are also invited and treated to dinner in which some sweet dish is served. Sometimes small presents are offered by the owner to the contractor and foremen of the main trades viz., carpenter and mason and plumber.

All this is not obligatory. But it is customary to do only the essential part of the ceremony and invite to dinner the important persons connected with the work. The cost of this ceremony may range from Rs. 15/- to Rs. 500/- according to the status and will of the owner.

HOW MUCH CAN I OR SHOULD I BUILD ?

We are now a definite step forward—we know our capacity to spend. After this we must see what our requirements are and how far they can be met from our budget.

The first step towards this end is to determine what size of a house it is possible to build within this amount and after that is known, to plan the inside arrangements. We shall assume for this purpose that after setting aside an adequate amount for meeting all the obligatory ceremonial expenses mentioned in the last chapter we have at our disposal Rs. 10,000/- for expenditure on the building proper and the plot together. Let us further assume that the plot which we have in view would cost Rs. 1,500/- maximum, including survey and legal expenses. This leaves us a balance of Rs. 8,500/- net for expenditure on the building only.

The size of the building which can be erected with this amount depends upon the kind of material we shall use and the refined arrangements and comforts we shall provide. It is just like travelling in a railway carriage. If we want the comforts and dignity of the first class, we can travel much less distance by that class than by the third with a certain fixed amount in our pocket. The railway rate is based on the number of miles travelled by this class or that; similar is the case of houses. It can be expressed in either of two ways: at so much *per cubic foot* of the house enclosed by its walls and the roof, imagining the house to be filled with solid contents; or at so much *per square foot* of the area of the plinth (length of the house multiplied by the width). The rate per cubic foot is a better guide as it takes into account the depth of the foundation and the height of walls as well. But the latter differ very widely in the different provinces of India on account of the climatic conditions and local practices. Thus in U. P. and Northern India 12 to 16 feet height

of the ceiling is very common in buildings even of the cottage type, whereas, in the Deccan and South India they are so low as 8 to 12 feet. Again, it involves elaborate calculations to find out the rate per cubic foot since the contents of the triangular shaped roof have to be added. We shall, therefore, apply rates based on square feet of plinth area basis as our standard of measurement. They are as follows :—

1. Medium dressed stone-in-lime masonry with cement pointing on the outside, or brick-in-lime masonry with cement plaster on outside in colorcrete; lime plastering inside; re-inforced cement concrete posts, partitions, beams and flooring; Bharat or similar tiles or polished Tandur paving in the drawing and dining rooms, Shahabad or similar slab paving on 3 inch lime concrete in other rooms; half panelled and half glazed doors; fully glazed windows; roofing on teak wood ceiling or re-inforced cement concrete flat terrace; height of floors 10 to 12 feet, that of plinth 3 feet; all other work of 1st class material and quality.

   Rs. 4-8-0 per square foot.

2. Rough dressed stone-in-lime masonry with cement pointing on the outside, or brick-in-lime masonry with colorcrete plaster on the front side only and in cement on other exposed sides, lime plaster on the inside; re-inforced cement concrete posts, partitions, beams and flooring, Shahabad or similar slab paving on 3 inch lime concrete in all rooms; Mangalore tiled roof on corrugated iron sheets or re-inforced cement concrete flat terrace; half glazed and half panelled doors in the drawing and dining rooms, plane planked in the remaining, fully glazed windows, height of floors nine feet, that of plinth 2 feet all other work strong, durable and decent but of 2nd class in quality.

   Rs. 3-8-0 per square foot.

3. Framed structure of round teak or re-inforced cement concrete posts with stone or burnt-brick-in mud masonry for walling; cement pointing on the outside, mud-plastering on the inside, shahabad or similar slab paving in the important rooms only, murum or mud flooring in the remaining; roof of round country tiles or mangalore tiles on battens or flat mud terrace; doors and windows all plane planked, height of floors 8′ that of plinth 1½′ to 2′.

Rs. 2-12-0 per square foot

The above constants are for ground floor structures only. For storeyed buildings four annas per square foot should be deducted from them.

From the above, it will be seen that with Rs. 8,550 in our hand we can have a single storey house.

of class I	1,888	sq. ft. or roughly	52′×36′
of class II	2,428	do	60′×40′
of class III	3,900	do	60′×51′-6″.

The rate for the upper floor is 4 annas less per square foot in each case, because you build the walls of the upper floor on the top of the lower one, no separate foundations, nor separate roof being required. It is easy to calculate the cost of a storeyed or a partially storeyed house e. g. the average rate for a two-storeyed building of class I is Rs. 4-6-0 of each floor separately or Rs. 8-12-0 of double floor. You can thus build within the above amount of Rs. 8,550/- a two-storeyed house of class I

972 sq. ft. or roughly 36′×27′ or

ground floor of 40′×36′ 1,440 @ Rs. 4-8-0	... Rs.	6,480
and upper floor of 27′×18′ 486 @ Rs. 4-4-0	... „	2,066
Total	... Rs.	8,546

When you know the size of the house which you can build with the money proposed to be spent, the next step is to allow for the thickness of walls and start planning of inside arrangements. This is the most important thing in a house and all the comforts, health and happiness of a family depend upon it. Good planning connotes, not only the placement of the several rooms so as to enjoy the sun and breeze whenever they are wanted and beauties of landscape, but also their sizes, their grouping, position of the windows, and doors for securing full freedom for the family as a whole and also individuals composing it, in the various activities, such as cooking, dining, relaxation, child-play, storage, study, toilet etc. etc. All this and several other matters closely connected with home life, have been treated in the author's "*Modern Ideal Homes for India*" to which a reference should be made. A perusal of that book is sure to give you an insight into the things which contribute to make a home the really sweet and cheerful home. When you are equipped with this knowledge, I would advise you to go to an architect and tell him your exact requirements and get a plan and an estimate prepared by him. He is specially trained in this art and his help in this most important matter would be worth far more than the ½% to 1% you will pay him for his fees. In this connection, I would advise you to go to an architect who has specialized in small house designs, in preference to the large firms of famous architects who might have designed monumental public buildings such as town-halls, palaces, post offices, cinema theatres and the like. For one thing, the latter will charge you more fees and for another, they may not supply you with as good, compact and economical plans as the small house specialist can do. Tell your architect that the cost must not exceed a certain amount, so that he will keep an eye on economy while designing your building.

HOW TO KEEP WITHIN THE ESTIMATE
or
WAYS AND MEANS TO ECONOMY.

When you get plans and estimates from an architect prepared in the light of your specific requirements, in all probability he will say that it is impossible to give you all you want within the amount, and you will find that his estimate will be much in excess of it. But don't be disappointed. You must make an attempt to adjust your desires to the depth of your purse. To do this scrutinize carefully every detail in the estimate, determine whether every individual item is really essential. If you cut down the non-essential things and strive to effect every possible economy in other ways you may afford a few luxuries also.

I append below a list of a few avenues to economy.

(1) The first and foremost is to get a plan and estimate prepared by a competent man if you have not already done so in which the thickness and sizes of materials such as steel girders, timber, re-inforced concerete members etc. are specified For, if undersized material is used, the structure will be weak, and heavy cost on repairs will soon be required. If, however, oversized material is used, that is a direct waste at the very start. He will specify just the proper size, consistent with strength and durability and thus effect a great economy.

(2) If a house is a straightforward rectangle in plan, it is cheaper than one with a number of projections. Again, the roof of such a house comes to be simple, economical, and less liable to leak. This does not necessarily mean that the house should be quite box-like.

(3) Unless the ground is sloping very much so that the plinth on the low side is more than 5 feet high above ground, a cellar is uneconomical.*

(4) A two-storeyed house is cheaper than a single storeyed structure for the obvious reason that no separate foundations and roof are required for the 2nd storey. Similarly, there is a saving in rain water gutters, drains etc. This holds good at the most for the addition of a light attic storey on top of the 2nd floor, as beyond that greater and stronger foundations and thicker walls are required.

(5) Draw out a plan for an ultimate house but just now build only the essential part of it, deferring the construction of the rest for the future, as and when funds are saved and as also your family's needs grow. The present construction also should be made in such a way that drastic changes will not be required when the contemplated additions come to be made.

(6) Reduction in the height of ceiling is a very sure way of effecting economy. In Europe and America 8 or at the most 8½ feet heights are used for ceilings of cottages. More height means more masonry of walls, greater number of steps and greater length of the straircase. Reduction in the height of ceiling also saves an effort in climbing the staircase. Further, a tall building requires thicker walls to enable it to resist the pressure of the wind.

(7) Only the outer walls should be built thick enough for stability, atmospheric agencies such as heat of the sun, damp caused by piercing rain and also for safety from burglers. All the inner partitions can be thin. This arrangement gives you larger rooms with a smaller amount. Even thin partitions can be sound proofed for privacy, if necessary in modern days at a trifling cost.

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* However, one such cellar specially built to serve as an air-raid precaution, even though uneconomical in the beginning, is a necessity in these days of modern warfare Please see the special chapter on "Home and Air-raid Precautions"

(8) Local usage and local material should be employed as far as possible. Imported materials and labour are always costly.

(9) In winter the days are short. Work cannot be commenced earlier than at 8 a m. and has to be closed by 5 p.m. as the workmen have to wend their long way home before dark. Thus with two hours respite for meals in the noon the working period is only 7 hours, whereas if the work is started in summer, particularly where the summer is not very severe, the working period from 7 a.m. to 7 p.m. with two hours recess is 10 hours—a saving of 23% in labour cost!

(10) If the work once started is allowed to progress steadily without a break and is finished expeditiously, the overhead charges and interest on the capital outlay during construction are less. Also if the house is occupied earlier, so much rent is saved.

(11) Think out the ultimate growth of the house in years to come and make provision accordingly. Thus, the present accommodation you need will be the nucleus, round which your extensions for the ultimate house will grow e.g. if another floor is to be added in future construct a flat terraced roof just now. The top of this roof will ultimately form the floor of the extension and the parapet walls when raised will be its walls and thus whatever is constructed today is fully utilised. As another instance, if a room or a verandah is to be ultimately added on a side, provide either holes in the walls to receive the beams of the room or the verandah or project the ends of beams of the inner rooms, for separate pieces of timber on the outside of the walls for resting the roof of the room to be added. This will obviate the necessity of dismantling any part of the structure to join the part to be extended.

(12) If you have not got sufficient money just now, but expect it some time later, then the construction or installation

of certain items can be deferred to a later date. A few important hints on such items are given below :—

(a) Verandah may be left open *i.e.* without railing, or simple parapet walls, or, simple railing may be constructed in them in the first instance, to be replaced by glazed windows later on as funds are available. This may save Rs. 200/- to Rs. 500/-.

(b) Some rooms may be left unpaved i.e. be content with murum or mud flooring for a few years until flag stone paving is constructed later. This may save about Rs. 250/-.

(c) If external walls are of brick, their joints may simply be pointed with cement now, the plaster may be deferred to a later date. This may save Rs. 300/-.

(d) Shutters of cupboards in walls may wait for some time. They will serve as open shelves for the time being. At the most cover them with a cloth curtain. This may save Rs. 125/-.

(e) Leave the rooms, you don't need to use immediately, unplastered. Leave all unimportant rooms even permanently unplastered e.g. fuel room, store, loft.

(f) Finish unexposed timber with simple varnish, or only linseed oil, instead of with costly paint, or use paint instead of enamel. This may save Rs. 50/-.

(g) Select simple water closet. This may save Rs. 10/-.

(h) Use ordinary glass panes to be substituted later by ornamental or plate glass.

(i) Choose cheap hardware such as hinges, tower bolts, aldrops, locks etc.

(j) Omit or defer installing costly electric fittings such as fans, ornamental shades etc.

(k) Even iron bars of windows may be omitted in the beginning if safety does not necessitate them just now.

(l) Shutters of ventilators over doors and windows in the inner walls may be differed for some time.

(m) Use cloth curtains instead of permanent inner partitions to start with.

(n) Give simple two coats of whitewash on the plastered surface of walls or at the most mix in it some Multan Mitti (yellow ochre) which gives a pleasant buff colour at a cheap cost. After a year or two the walls may be distempered.

(14) Build the stair-case between two thin partitions and save the cost of side timbers and ornamental railing and balustrade.

(15) Instead of cut stone steps which are very costly, use brick or rubble masonry steps covered with flag-stones with rounded edges.

(16) Think hard in the early stages but once the work is started don't make any alterations afterwards Changes made at the eleventh hour may land you in great difficulties, financial and others.

(17) If the foundations are good omit altogether the coping at plinth level and save at least Rs. 150

(18) Last, but not the least important is the advice to restudy each item, cut down unessentials, and decide once for all what to allow and what to sacrifice and once this is done to adhere to it with utmost determination. Don't listen to your friends' advice though well meant, for effecting changes. Indecision and vacillation are both very bad. Write down the ultimate figure you have decided to spend, in your diary or your calendar Hang it in bold figures on the wall in a prominent place in your room and when friends, salesmen and others tempt you by offering suggestions to spend more steal a glance at the figure and it will give you courage to control your desires to put up a definite "no."

THE FINANCIAL ASPECT

OR

HOW TO RAISE MONEY.

When you are short of money to build your house, the most obvious way to make up the deficit is by raising a loan on mortgage. Some people might feel shy and would not appreciate the idea. But there is nothing wrong, nor derogatory in it. It is the accepted way to finance a housing scheme and one need neither apologise for it, nor regret it afterwards, provided one does it cautiously with honest intentions of abiding by the terms of the agreement. In that case there is very little risk in it.

For doing this you must have your plot ready so also your plans and estimate, without which no lending agency would ever care to talk seriously with you.

Until a few years ago Government in the Co-operative Societies Department used to lend money to Co-operative Housing Societies at 5½% interest on long terms of 25 to 40 years. But unfortunately they have now discontinued it.

There are several sources now available from which you can borrow a loan—

(1) By private mortgage;
(2) By ordinary bank loan;
(3) By a co-operative bank loan, and,
(4) By an endowment assurance policy.

A private mortgagee (one who lends) is a person possessing capital to invest, who advances a loan on the security of the house to be purchased or built together with some other collateral security. The rate of interest may be anything mutually agreed upon between the parties. The mortgagor (one who borrows) pays only the interest annually or six-monthly and the principle is payable in a lump sum at

the end of the period. He may be required to insure the property against risks and maintain it in a proper manner. The mortgagee usually reserves to himself the right to review the transaction at stated periods. This means that he might either call in the loan or might increase the rate of interest. The loan may be called back at a very inconvenient time.

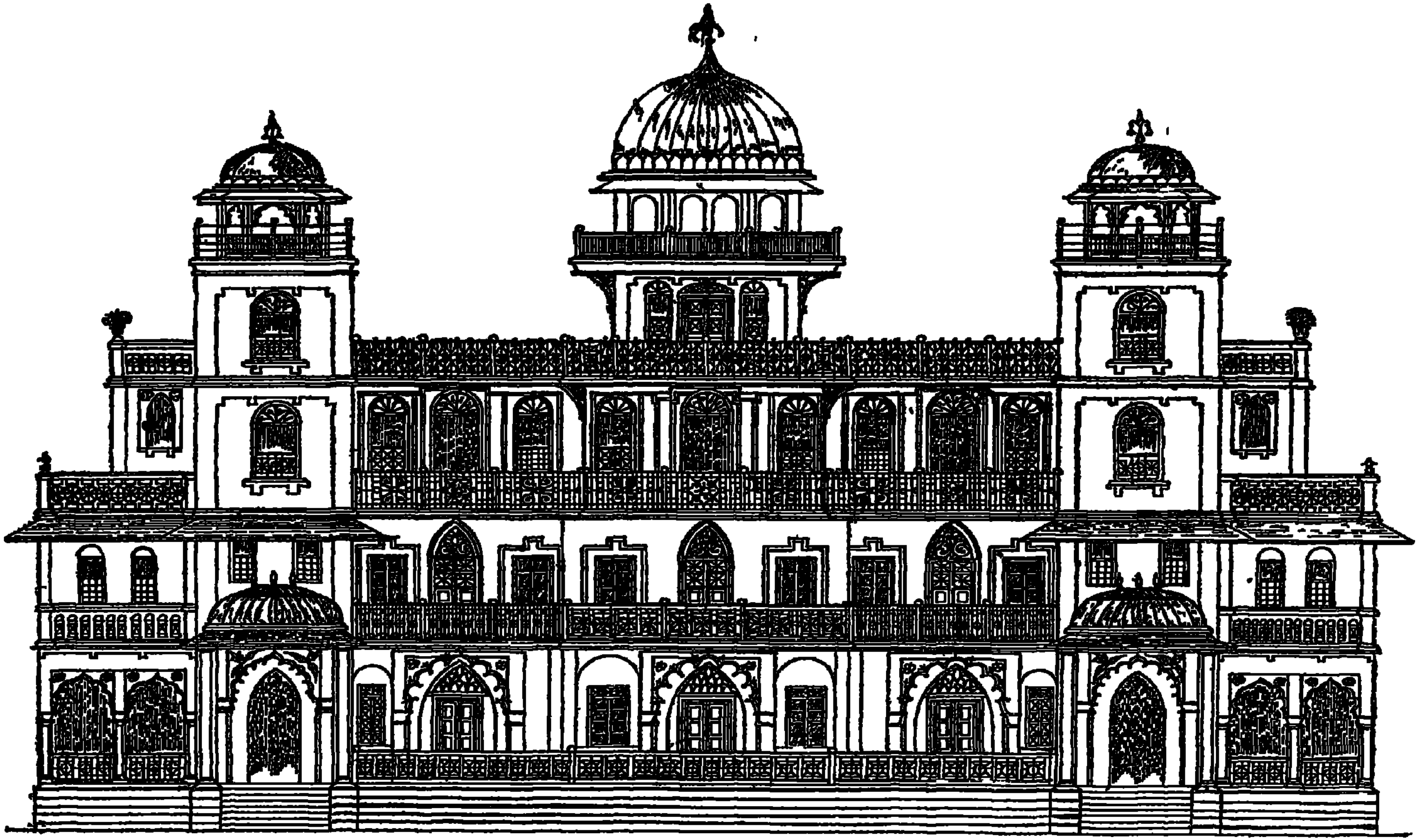
If the interest is not paid in time the mortgagee may sue, take possession of, and sell the property according to the agreement.

Now-a-days banks offer so many facilities that nobody would borrow a loan from a private person, unless he be a friend and be advancing it at a very low rate of interest.

(2) Ordinary banks advance loans but usually for very short periods. They are, again, usually very conservative in the matter of valuation of the property and thus the advance offered may be quite insufficient unless some other collateral security in the shape of other property is given. The rate of interest charged is slightly higher than the then current bank rate *i.e.* the rate at which the Reserve Bank of India discounts approved bills.

The loan from ordinary bank may prove to be convenient, when it is required for a short term, e.g., when one has to buy a new house before he has been able to sell his old one and such other circumstances.

(3) Co-operative banks offer much better facilities for buying or building houses. They do not require other collateral security. You have, however, to collect a minimum of ten members including yourself who want to build their houses and form a co-operative housing society. An application signed by them all is to be submitted to the Registrar of Co-operative Societies on a printed form. He supplies you a copy of the printed booklet "U" in which detailed information regarding your obligations as a member of co-opera-



FRONT ELEVATION.

Fig. 6 A Palatial Building of large proportions in Conventional architecture

tive housing society, the model bye-laws etc. are given fo. your guidance. As soon as the society is registered you are admitted to the privileges. Formerly, they were many, ranging from exemption from stamp duty to the sanctioning of long term loans upto 40 years at a reasonable rate of interest. But Government have now withdrawn most of them. Still one of them is that Government may acquire land for your housing society under powers of the Land Acquisition Act. If you have already purchased land you can straight apply for a loan through your society to a co-operative bank. They send their engineer to scrutinise your plans and evaluate the land and the house from the plans and specifications. They then sanction the loan to the maximum extent of 75% of the total value of the proposed building and plot together, made by their engineer. A few years ago they could sanction it for a long term upto 20 years, but recently Government have put restrictions on the period and reduced it to 10 years. Before the loan is sanctioned you have to become a shareholder of the bank by purchasing shares of the bank to the extent of 6¼% of the loan. The amount is paid in several instalments. For example, if you have already paid for the land you can expect cash upto 75% of its value made by the bank's engineer, in the beginning. With this and some of your own money you can build up to a certain stage, say, upto the plinth level. You have then to submit a statement of the work done and also the materials brought on site and apply to the bank for a further instalment. This will be scrutinised by the bank's engineer and upon his recommendation being received the bank will advance a further amount of 75% of the engineer's valuation of the work done and the materials at site and so on, until the whole building is completed. The latter is then mortgaged to the bank through your society and you have to pay regularly every month the instalment fixed by the bank which includes the interest and part of the principle and thus as you pay you reduce

your debt little by little until you don't owe anything, · the deeds are released and the house becomes unencuml property of your own.

This is an excellent scheme, the only draw-backks l (1) that as the period of loan is only ten years the instaln are bound to be rather heavy and (2) that in the event of den death of the mortgagor during the term, there is no tection for the dependents.

In this respect a transaction with a Life Insurance (pany is advantageous but a premium on insurance ha be paid in addition to the interest on the loan.

(4) **Endowment Assurance Policy.**—A number o: surance companies and a few estate companies operate h purchase schemes. The advance is made on the seci of the house either to be built or purchased, together · collateral security of an endowment assurance policy on life of the house builder or purchaser.

To take a concrete example, * let us suppose that Mı Y. Z. aged 30, wants to take advantage of the scheme has purchased a building plot costing Rs. 1,000/-. Bes this, he has saved an amount of Rs. 500/- and wants to b a house, the estimated cost of which, is Rs. 4,500/-. thus needs Rs. 3,000/- to fulfil his desire. An insuranc(estate company will be prepared to advance him a loaı Rs. 3,000/- provided he agrees to mortgage the plot with company and further insure his life for Rs. 3,000/- and as the policy to the company. The company may either the amount in cash in several instalments at certain st of the building as it progresses, or, if it has engineering e blishment, it may also supply a plan according to his (requirements after consulting Mr. X. Y. Z. and build it th selves. At any rate, as soon as the house is ready for occı tion it will be placed at his disposal and the monthly ins

* By courtesy of the Hindustan Housing Co., from whose printed booklet the example is taken.

ments for the dues of the company will commence. Let us suppose that Mr X. Y. Z. chooses to insure his life for a period of 20 years; he has to pay a monthly instalment of Rs. 48/- which includes both the premium on the policy, part repayment of the loan, and the interest on it.

In 20 years this will amount to Rs 11,520. In return he will receive Rs 3,000/- in the form of the house and a cash amount of Rs. 4.200/- (the endowment policy being with profits). i.e. Rs. 7,200/- in all. Deducting this amount from Rs 11,520/- a balance of Rs. 4,320/- is left which can be regarded as the rent the company takes for the house for 20 years. This rent works out to Rs. 18/- per mensem only.

The advantages of this scheme are.—

(1) As a good insurance or estate company is a permanent investor, the chance of the loan being suddenly called in at an inconvenient time can be disregarded.

(2) In the vent of one's death, the loan is automatically discharged by the Assurance Policy, and there is thus no fear of leaving a burden upon dependents.

(3) One is entitled to a rebate from income-tax in respect of one's premiums and as interest on mortgage is a direct charge on income there is a further reduction in income-tax (of course, if the income reaches taxable limit).

(4) One gets a house of one's own choice to live in, in a few months after one has made the agreement.

(5) One becomes an undisputed master of a home for the mere payment of rent to a company for a fixed period, which in any case one would require to pay to a landlord.

(6) The home will be his, in spite of death and accidents such as fire or earthquake.

(7) One saves and accumulates, in addition, a decent sum which would be very useful to him in his declining age.

If it is found that the instalment in the above scheme is too heavy to bear, one can purchase a life policy instead of an endowment, the premiums of a life policy are always much lower.

To illustrate this, if the above gentleman, Mr. X. Y. Z., chooses to purchase a life policy he will have to pay:

Annual premium towards the repayment of the loan of Rs. 3,000/- in 20 years	Rs.	120	0	0
Interest on the loan at 5½% per annum. ...	Rs.	165	0	0
Annual premium on whole life policy	Rs.	88	4	0
Total per year	Rs.	373	4	0
Deduct income-tax on (165 *plus* 88-4) 253-4 at say 6 pies in a rupee	Rs.	11	10	0
	Rs.	361	10	0
Monthly instalment 1/12th of this	Rs.	30	2	0

This is much less than the above and still he gets all the advantages of the above scheme particularly the most important one viz. that in the event of his death his dependents will receive sufficient money from the Assurance company to pay off the outstanding mortgage. Further, the sum becomes increasingly greater as time passes on but it will not be received in his life time.

CHOICE OF SITE
OR
WHERE TO BUY LAND.

This subject is so important that I am tempted to give full details here from my book on planning even at the risk of repetition.

A good house on a poor site would neither contribute to happiness nor prove to be a good investment. When you buy a site, not only you buy the piece of land, but you buy with it the environments and the neighbourhood, you buy *i.e.*, settle once for all the people with whom you will mix and talk in streets or in a club or place of congregation, you, buy the beauties of nature, you also buy your social status. The lay-out and also the architecture of the building to be erected depends upon the site. Hence the importance of this question.

But unfortunately, very few people use the necessary commonsense in selecting a site. With many people, the only consideration is the proximity of their house to their business or place of service. Many are attracted by their friends or relations living in a particular locality.

If there are several alternative sites fulfilling your main requirements, it is advisable to go over every one of them in company with your wife and friends and better still with an architect and discuss all the pros and cons of each in the light of the twentysix suggestions made below in this chapter before finally deciding on buying one of them.

The considerations which should govern the selection of site are given below. It is almost impossible to find such an ideal plot of land fulfilling all the conditions. However, they will remind you of all desirable things at a glance,

and it is for you to discriminate those points only on which you think greater stress should be laid.

(1) Select a site in the midst of a suitable neighbourhood, in which your family will enjoy the full social pleasure and not feel ostracised. The social status of the people in the neighbourhood should neither be too high, nor too low as compared with yours. You can't say "I don't care for my neighbours" and retire behind a high compound wall or hedge. Your children, in divine innocence, natural to childhood are sure to mix freely with your neighbours' children in spite of yourself. Fifty per cent of the pleasure will be lost if the neighbours are not of the proper type.

(2) Buy a plot where land has fully developed or has already been under development or at least where there is a definite trend of movement of population in that direction. Such a plot might be a little more expensive, but you tread on sure ground. If the locality is undeveloped it is only by chance that you may get the right sort of people coming in as your neighbours. The quiet atmosphere in the beginning, which gives it a touch of rural life, which you love most, may in course of development be converted into a busy shopping area full of noisy traffic or it may not develop at all leaving an atmosphere of loneliness round your house.

(3) A free-hold is the best. If it is lease-hold, the period of the lease should extend over at least 199 years.

(4) Buy land where there are bye-laws framed by a local authority enforcing permanent restrictions such as fixing the maximum proportion of built-up area to the area of the plot, space in front and on sides, height of buildings, separate zones for industrial and residential areas etc. etc. They no doubt restrict your liberty, but they are very desirable as they protect you against unscrupulous people having commercial tendencies, who build on every inch of available

land to earn profits, unmindful of the inconvenience and nuisance they cause to their neighbours and the neighbourhood.

(5) Buy a plot in a locality where you can build according to your own standard of living. The restrictions of the place may not suit you. They may either require you to build according to a particular standard which you cannot afford e.g. one building only in one acre of land etc. or they may fall short of your ambitions or aspirations e.g. you want a garage for two cars, while restrictions will allow you only for one; you want to keep poultry or a milch-cow which the bye-laws might forbid you to have and so on.

(6) Buy a plot where water supply, electricity, roads, drainage etc are already provided; (if there is no piped water-supply, there should be a well with good potable water preferably a private one in your own compound). If the area is not fully developed and these utility services are to be provided in future, your share of the expenditure of providing them might perhaps be too heavy for you to bear.

(7) A school, a post and telegraphic office, a public telephone, a bank, a hospital, a maternity home, market and such other public conveniences should be within reasonable walking distance from your building site. It is particularly a great advantage for your children to be able to walk to their school without having to cross a heavily trafficed road.

(8) If possible, a fire brigade and a police station should also be close by.

(9) There should be good transport facilities such as railway, tram or bus service for going to office, college, shopping centre, etc. Measure the distance not in miles, but in time it takes to go there.

(10) The site should be free from traffic dangers and noise. A busy street might prove to be a menace to your children and to your daily comforts in respect of nightly

slumber particularly during sickness. Besides the traffic raises dust, full of dangerous bacteria, which settle on your food and drinking water.

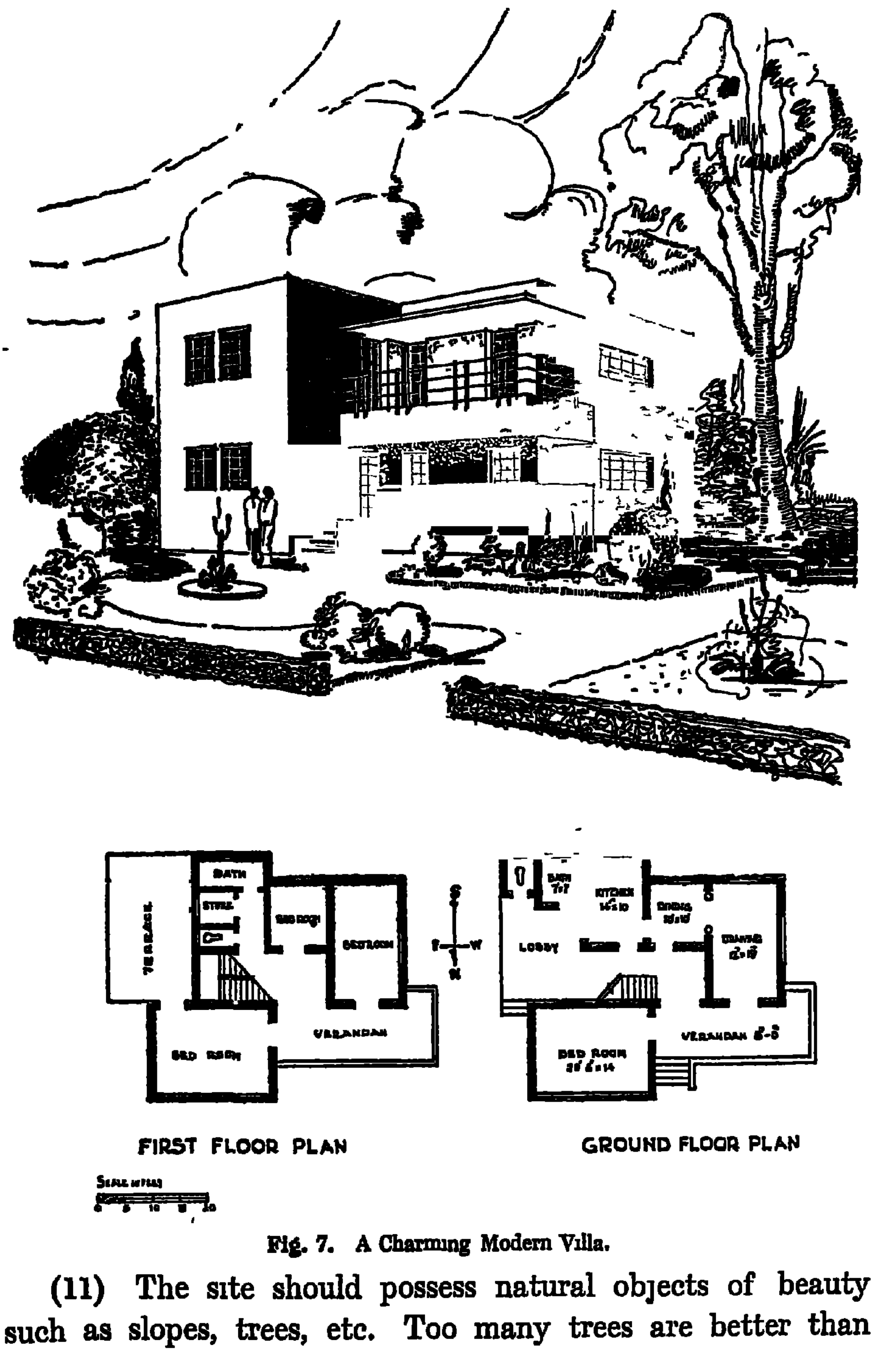


Fig. 7. A Charming Modern Villa.

(11) The site should possess natural objects of beauty such as slopes, trees, etc. Too many trees are better than

too few. The site should command a good view of landscape such as a hill, river, lake, etc.

(12) The frontage and width of the plot should be a minimum of 50 feet. Enough area should be purchased in the first instance, even if you have to curtail the size of the building to pay for that, because with the growth of your family, you will require to extend your house. Again, if you don't need a garage and servants' quarters just now these may be required later on, and it would be difficult, expensive and perhaps impossible to acquire more land for them afterwards.

(13) There should be firm soil, sand, muram or rock within a reasonable depth say 2 to 5 feet below the surface for foundations. In no case should the land be of "made soil" (*i.e.* once a depression, filled afterwards with dung, litter or even earth and debris). Besides being insanitary there is always the danger of such soil settling down unevenly and obstructing drainage; the first causes cracks in the building, while the other is detrimental to health.

(14) There should be ample unobstructed sunlight and breeze to ensure health and comfort to your family.

(15) The site should be on an elevation and further, should be either level, or uniformly sloping and not undulating or full of depressions. If it is low-lying the cost of raising it above the street level might be considerably expensive. An elevated site with slopes, drains away rain water immediately and keeps the house dry. It also commands a wider view and adds to the dignity.

(16) The surface should be of good garden soil. If it is rock, you save in foundations but then excavation for drains becomes very costly. Besides, you are permanently deprived of the pleasure of a garden and good trees. The ideal conditions are that there should be two to three feet of black or red soil overlying sand or muram.

(17) The shape of the plot should not be very irregular. Instead of a mathematical rectangle, if it is slightly irregular, it looks more artistic. But if it has too many acute corners and irregular boundaries, its area and cost proportionally increase without giving any advantage of space. The length of the fencing also is unnecessarily added to.

(18) There should be no easement rights in the plot. Easement is a right possessed by a municipality or a public utility company for laying pipes, erecting poles or to inspect, dig up, or repair their property which lies or runs through yours.

(19) A corner plot is a luxury but it is an expensive luxury. Unless it is situated on quiet roads it often proves a nuisance. It costs more, requires a longer fence or compound wall, two attractive elevations of the buildings, and unless the plot is large enough to instal the building far inside the two fronts, you are likely to lose your privacy from the highways.

(20) Before buying the plot, see that the title is clear. This is a very important matter and a small expense incurred in getting letters of administration through a lawyer is worth it. If you borrow money from a lending agency the latter will do it for you, of course, at your expense.

(21) Don't buy a plot with inexact boundaries. Get it properly surveyed to the precise feet and inches on every side, and demarcated by permanent fencing. Don't depend on the seller's word that your land is "from about here to about there." Get the lines correctly established after verification by your adjoining neighbours, at the time of searching the title.

(22) Don't invest more than 30% as a maximum of your total money earmarked for the housing project into the plot of land, if the property is fully developed with all the amenities, such as, water supply, streets, light, drainage

or conseravancy etc In up-country places where these amenities are partially supplied no more than 5 to 10 per cent should be invested.

(23) Don't buy a plot on which a lending agency is not prepared to pay a loan of at least 40 per cent of the cost you have to pay. This is a sure test of its real value. If they pay 50 per cent and above take it that yours is an excellent bargain.

(24) Make enquiries about the future assessment. If the land is classed as agricultural land, the annual revenue assessment might be from Re. 1/- to Rs. 10/- per acre. But as soon as it is used for non-agricultural purpose it is liable to enhancement from anything to as much as Rs. 1,500/- per acre per year.

(25) Avoid a site in the neighbourhood of quarries, brick, lime or charcoal kilns, nallas which are not kept clean and may breed malarial mosquitoes or a place to which winds will carry dirt and smells of industrial plants such as tanneries, paint factories, etc.

(26) Don't make haste in buying; take time to look at the bargain from every side, and in spite of this if you have purchased it and later find that it was an unwise move, don't make another error of building on it. Sell it, abandon it, give it away in charity, or do anything else except building on it.

PLANS.

OR

The Language of the Draftsman.

The plans usually required in connection with a building are: (1) A site plan (2) Floor plan, one or as many as there are floors, if they are not all alike, (3) Elevation—on one side or more. These are necessary and all together go under the name of "plans."

In addition to these, sometimes the following two more are prepared viz., (5) A perspective view—one or more from different positions and (6) Landscape plan.

(1) A site plan consists of a drawing, in which the location of the particular building in the particular plot is shown with reference to the surrounding building plots, and particularly the nearest street or road giving access to the place. It includes: (a) Lengths of boundaries of the plot showing its outline, with its distinguishing number or mark such as plot No., survey No. etc., (b) The plots adjoining it on all sides with their numbers (c) The nearest street and road or lane giving access to the plot (d) The north direction shown by an arrow with the letter 'N' drawn at its head (e) The exact location of the proposed building, out-houses and other permanent structures in the plot (usually shown in red) and the space proposed to be left between the building and boundaries of the plot on all sides (f) The proposed drainage lines whether under-ground or surface drain, with inspection chambers etc. (also shown in red) and the place to which they are finally carried such as a municipal sewer, street gutter or a nalla.

The above six details are necessary both from the point of view of municipal requirements and common understanding of the plans. But in addition to them, the following details are very helpful for the arhchitect or the engineer who

designs the building and prepares an estimate of cost : (g) The direction of the prevailing wind (shown by an arrow inclined to the north line) (h) The direction and amount of the downward surface slope of the ground shown by an arrow like this → "1 foot in 60 feet;" (i) Results of pits excavated to see what sort of foundations are available and at what depth. If the strata below ground are uniform, only one or two pits near diagonally opposite corners of the proposed building are sufficient. If they vary, a pit at each corner is required.

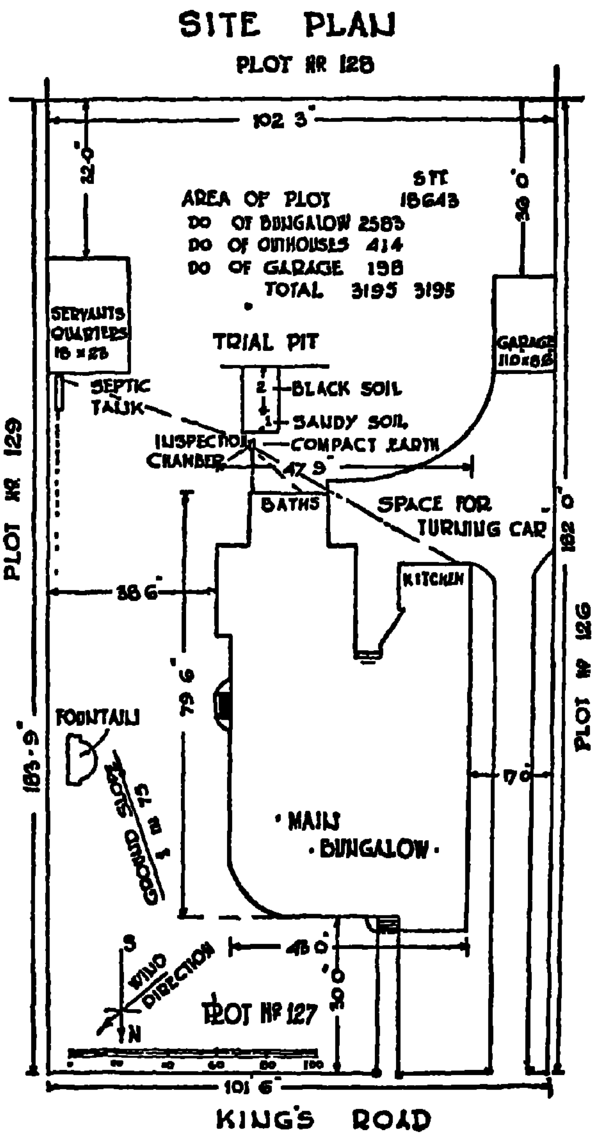


Fig 8. shows a typical site plan showing all the details mentioned above.

(2) **Floor plans** of as many floors as the building may have, of course, if they vary. Otherwise, only one is sufficient. It shows the general arrangements of different rooms,

the length and breadth of each individual room, thickness of walls, positions of doors, windows and cupboards, etc. and all that could be seen in a horizontal plane.

In a very carefully drawn floor plan, in addition to the above details, each individual room is separately planned in respect of the furniture and fittings, e.g. in bed rooms the position of beds, clothes closet, dresser, writing table, chair etc. are shown to scale in their proper positions; in a kitchen, the range, sink, cabinets, table, refrigerator etc. are shown and so on. Besides these, positions and various kinds of electric fittings such as wall-bracket, pendant, buzzer, telephone, fans, etc. are shown; also, the direction in which the doors open, beams, trusses, etc. etc. Some of these are shown by symbols which are universally accepted.

Figure 9. shows floor plan of a single storeyed cottage, in which most of the above details and sanitary fittings in bath rooms are shown.

(3) **Cross section.**—This may be rather difficult for a layman to understand, but it is very important to the contractor and the supervisor. Because, it shows to them the architects' ideas at a glance, which cannot be seen in any other drawing, e.g., there are a number of important details in the vertical plane which cannot be shown in a floor plan, such as, heights of windows, and cupboards and their positions above the floor level, heights of posts, ceiling, roof, etc. thickness of floor and beams, width, thickness and depth of footings of foundations below ground and so on. All these cannot be shown except in a cross section. While drawing the cross section, the architect or the engineer imagines himself to be walking along a particular line shown on the plan and records vertical lines of all the details he sees from the roof to the foundations. Parts which lie exactly on the line of the cross section will be seen in section *i.e.*, cut by a vertical plane. Those beyond the line will be seen in elevation *i.e.* whole

(not cut). Whether they are on the line or beyond it, they are all shown in one vertical plane.

Figure 10. shows a cross section on the line A. B.

(4) **Elevation.**—This is also important. The architectural beauty of a structure depends upon the relative proportions of the different parts to each other and also to the entire facade of the structure. They must form together a harmonious combination pleasing to the eye, and this can be seen only in a view of that side drawn to a scale. The type and location of windows, placing of doors, the designs and location of balconies, the roof lines—all these influence the outside appearance. If the view drawn in this way looks dull, the architect brings out some central feature which at once makes it attractive.

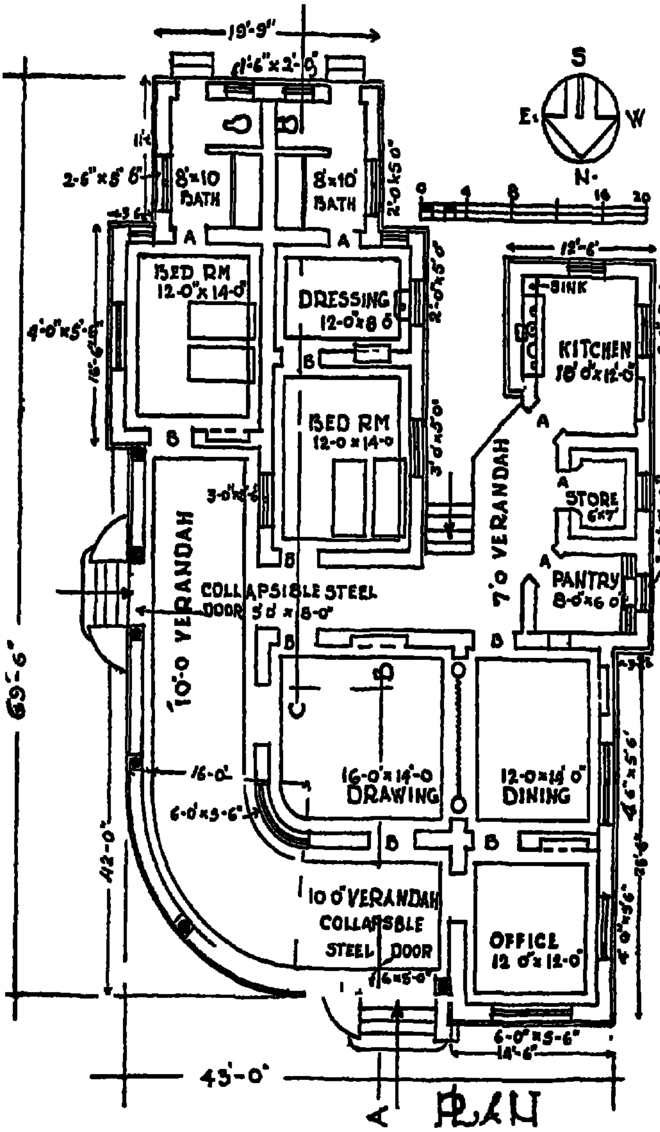
Elevations are usually flat *i.e.* they lack perspective. In a photograph or in a picture, the nearer object looks larger and distant one, though of the same size, looks smaller. But in an elevation, both near and distant objects are drawn to their actual size. Further, objects are drawn as if the observer were on a level with the top and bottom of the house at the same time. This makes it rather difficult for a layman to understand it properly; still, it gives a good idea as to how the building will look on a particular face.

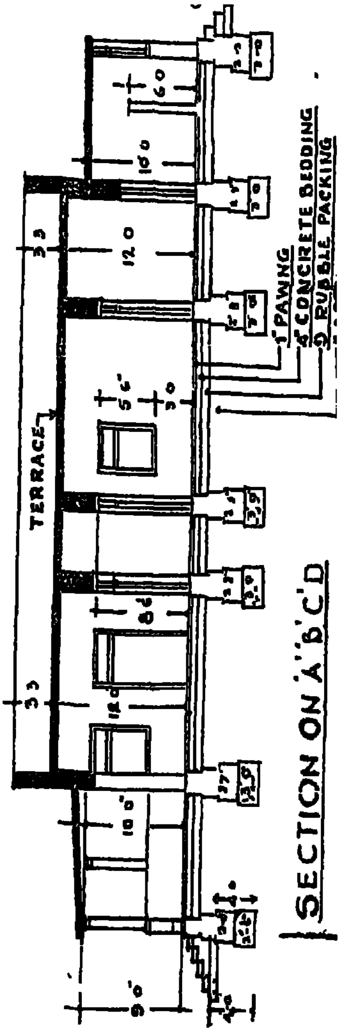
Figure 11 shows an elevation of the same building from the North side.

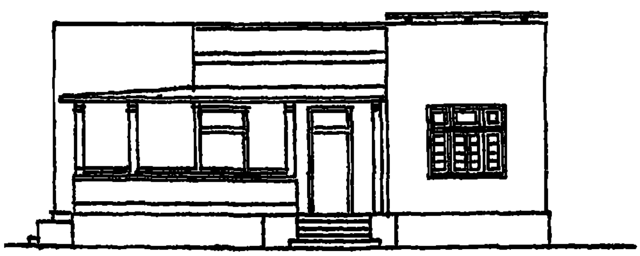
When the work is important, elevations are drawn not only on the front, but also on sides. A house situated in a corner plot has to face two roads, hence, two elevations are drawn.

In addition to the plans mentioned above, detailed drawings of certain more important intricate parts are drawn to a large scale for the guidance of the supervisor and the artisans.

Perspective view.—This represents a picture of the proposed house closely resembling its true image as in a pho-







ABOVE. Left—Floorplan Fig 9

Right—cross section Front on ABCD Fig. 10

LEFT. Elevation Fig 11

BELOW Perspective View from N E corner Fig. 12

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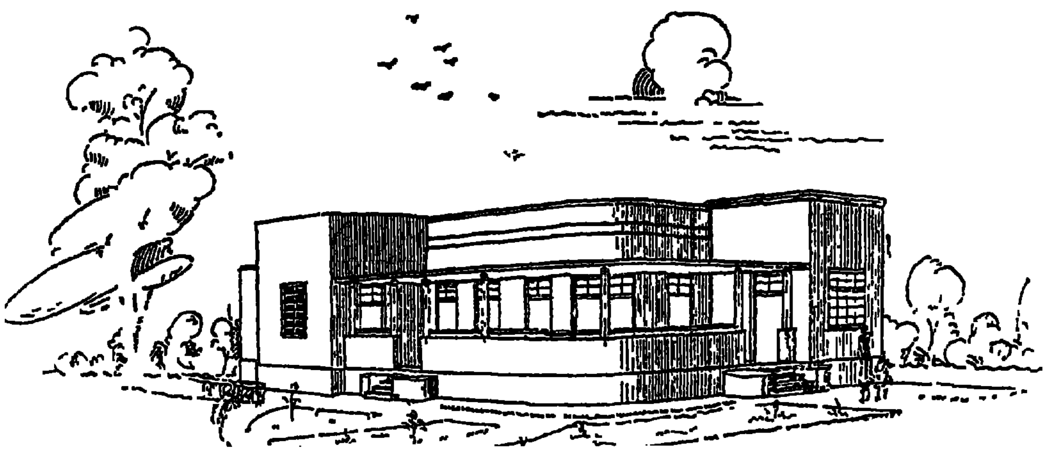

tographic reproduction of the finished product. Such drawings are prepared, because, few people can really understand the working drawings and can visualise the true appearance from a flat elevation.

Figure 12 shows a perspective view of the same building drawn from the North East corner.

Then again is the landscape plan, in which, the dispositions of the various plantings, shrubbery, paths and car drives etc. are shown. The beauty of a building is enhanced by creating surroundings and giving an atmosphere to it which will mark it as an abode of people of taste and refinement. Besides, the science of psychology has proved in modern times that environment has so much to do with shaping our lives and dispositions and that neatness and beauty of our home surroundings are elevating and moral. Hence, the people who know the importance of this, place their homes amidst surroundings designed according to a pre-conceived landscape plan.

Figure 13 shows a landscape plan of the same house.

Thus plans transmit ideas from the person who conceived them to those whose responsibility it is to work the scheme into material form. The draftsman's language is capable of expressing information and ideas which cannot be adequately explained by spoken words and since its symbols are universally accepted in all countries, it is a universal language as far as that art is concerned.

Estimates.—With plans usually goes the estimate. The latter consists of two parts (1) The detailed measurements of each item such as, excavation, concrete, wall masonry etc. and (2) The abstract of quantities of each item and rates, from which the final cost is worked out. The details which are not shown in the plans will be found by a reference to the first part of the estimate *viz.* measurement sheet. The second part or the abstract sheet gives quantities, rate & their values.

SPECIFICATIONS OR THE BYE-LAWS OF CONSTRUCTION.

When a work is entrusted to an architect he gives you along with the plans and estimate, sheets of specifications either typed or printed. These are the detailed instructions describing the quality and sizes of materials, the manner of using them and particularly the things which he insists upon, and those which he wants to be avoided in the construction. In fact these are the bye-laws framed by the architect for ensuring the soundness of work. These form the primary basis on which the constractors submit their tenders. Good specifications should contain, even at the risk of redundency, the minutest details. For, if a difference of opinion arises between you and the contractor a reference to the specifications will settle it, if there be mention made in the specifications. If not either you must allow the contractor to have his own way, or if you want it done your way it will be treated as "extra" and you must be prepared to pay separately for it, over and above the estimate. In the matter of the extras you are at the entire mercy of the contractor. Because, if he quotes unreasonably for them, you cannot get only that much part of the work done by another contractor, and thus you have ultimately to yield. At any rate it gives rise to a cause for friction between you and the contractor.

If the specifications are brief, much is left to the sweet will of the contractor. For instance, unless the specifications insist on cement plaster to walls in a particular room, the contractor will obviously apply chunam plaster, because, it is much cheaper; unless the specifications insist that the earth from the foundations must be carried at least so many feet away from the building site and spread there uniformly, the contractor will make a heap of it close to the foundation trenches and you have ultimately to lift it again at your expense, and spread it out.

When you do not entrust your work to a contractor, but do it yourself on daily wages there is no need of specifications.

Typical specifications are given in the following pages.

SPECIFICATION.

(GENERAL.)

1. The Contractors will be required to provide to the satisfaction of the Architects, a fully qualified and trustworthy general foreman, who shall be thoroughly experienced in building or Engineering works and who will be always upon the premises when work is going on The Architects are to have full power to require the Contractor to remove such a foreman from the works with 24 hours notice to the Contractor, who is immediately thereupon to appoint another foreman acceptable to the Architects The Contractor shall provide office accommodation for the foreman as may be necessary

2 The Contractors shall give to the Municipal, Police and other Authorities all notices, etc, that may be required by law, and obtain all requisite licenses for temporary obstructions, enclosures, openings into common sewers, water pipes etc, and pay all proper and legal fees and charges to such Municipal and other Authorities, and also to neighbouring proprietors whenever necessary. The Contractors shall make good any damage to adjoining premises, whether public or private, and keep up lights, etc, required at night They shall also construct proper enclosures and fences for the protection and convenience of the work people and the public during the progress of the works, and perfectly restore the adjoining grounds, pavements etc, on the completion of the work The contractors will pay deposits and make all arrangements and pay the water charges for the construction work

3 Figured dimensions on drawings shall supersede measurements by scale, and drawings to a large scale shall take precedence of those to a smaller scale Special dimensions or instructions in the Specification shall supersede everything else

4. The Contractors shall provide suitable stones with flat tops and build the same in rubble masonry for temporary bench marks All the pegs for setting out the work and fixing the necessary levels required for the execution thereof shall, if desired by the Architects, likewise, be built in masonry at such places and in such manner as the Architects or their Assistant in charge of the work may determine

5 For all purposes connected with the work the Contractor is required to make his own arrangements for a sufficient supply of water of a quality and quantity and at such places on the work as may be ordered by the Architects The rates quoted in the Contract are for completed work and hence shall be taken to cover all Contractor's costs in supplying water to the terms stipulated in the clauses of this Contract In case the Contractors want to make use of plots adjacent to the Owner's for stacking materials etc, they have to approach the Owners of those plots or such other Authorities and make their own arrangements The Owner will not be held responsible for any complaints on this score from anybody

6. Wherever shoring may be deemed necessary by the Architects, the Contractor shall provide the same in the best possible manner with the best materials and to the satisfaction of the Architects The Contractor shall employ such kind or kinds of shoring as the Architects may consider the exigencies of the work require, and it is to be distinctly understood that the work 'shoring' is to comprise all classes of such work and all appliances and appurtenances, including poling boards, and runners (wherther the

joints be butt, groove and tongue, feather-edge and groove, bird's mouth and double splay, rebated or otherwise), together with walings, struts, props, point-blank shores, blocks, wedges iron dogs, bolts, screws, nails and everything that may be required for the due execution of the work.

7 When a trench passes near houses or other buildings, the Contractors shall at their own cost properly and securely shore such buildings and adopt such other precautions as may be necessary under the circumstances of each case After the work is completed near such buildings, the Contractors shall remove the shores and make good any cutting out or other damage that may have been done

8 The Contractor will be required to provide and work at his own cost all pumps, engines and machinery requisite to keep the trenches for the sewers, drains or foundations and all other excavations clear of water, so that no masonry may be laid, no concrete deposited, and no joints made in water, and the pumping shall be continued so long after the execution of any portion of the work as the Architects may consider necessary for the same to set The pumps and power applied must be such as the Architects may determine to be sufficient at any particular time or they may themselves supply pumps and power at the Contractors' expense, or they may stop the work altogether until they are satisfied of the adequacy of the pumps and power supplied by the Contractors For the purpose of keeping the excavations as dry as possible the work will, if necessary, be divided into sections or separate portions to be determined by the Architects and temporary dams will have to be put up by the Contractor, sumps for the suction pipes to work in, will have to be excavated by the Contractor at such distances apart and to such depths as the Architects may determine When the work progresses, other sumps must from time to time be excavated by the Contractor, the disused sumps being filled up by him with dry rubble carefully hand-packed to the satisfaction of the Architects The Contractor will not be paid extra for any temporary dams or sumps or their removal or refilling, nor will such work be taken into measurement in any wise

9 All water pipes, gas pipes, existing drains or any other works which may be met with in or about the excavation shall, if the Architects deem it practicable, be properly maintained by the Contractor, and by means of shoring, strutting, planking over, or otherwise, as the Architects may direct, shall be protected by the Contractors from damage during the progress of the work, or if damaged shall be made good by him at his own expense If, however, the Architects consider that it is not practicable for the Contractor to maintain any such pipe drains, or other works, and that the exigencies of the work necessitate the temporary breaking down or removal of the permanent diversion of any such pipes, drains or other works, then though the cost of breaking down or removing the same and (in case of drains) the cost of providing such chutes or other appliances as the Architects may direct for the temporary passage of the water or sewage shall be borne by the Contractors, yet the cost of rebuilding, replacing or diverting the same, if such rebuilding, replacing or diversion is required by the Architects, shall be paid to the Contractor

10 All the materials to be used in and about every part of the work may be from time to time subjected to tests by means of such machines, instruments and appliances as the Architects may direct, and wholly at the expense of the Contractors.

11 Every portion of the work shall be kept clear of accumulations from time to time and delivered up clean and free from all defects of every kind at the conclusion of the works

12 Notwithstanding that all reasonable and proper precautions may have been taken by the Contractors at all times during the progress of the work, the Contractor shall nevertheless be held entirely responsible for all damage, whether to the works themselves or to any other property or to the lives, persons, or property of others during the progress of the works and the period of maintenance

Excavating Foundations.

13 Trenches for foundations, footings, cesspits, drains etc to be excavated to the exact width, length and depth shown or figured on the drawings or as may be directed by the Architects If taken out to a greater width, length or depth than shown or required, the extra work occasioned thereby shall be done at the Contractor's expense Extra depth shall be brought up by sound masonry or concrete filling and extra length or width filled in by rammed earth or mooram if the Architects think it necessary for the stability of the work by masonry or concrete as may be directed The excavated material shall be used for filling on each side of the masonry or as may be ordered, free of charge The Contractor shall, at his own expense and without extra charge, make provision for all shoring, pumping, dredging, bailing out or draining water, whether sub-soil or rain water, and the trenches shall be kept free of water while the masonry is in progress and till the Architects consider that the mortar is sufficiently set The sides of the trenches to be kept vertical and the bottom horizontal, and to be run at the same level throughout or properly stepped as may be directed by the Architects The Contractor shall also, at his own cost, remove such portions of boulders or rock as are required to make the bottom of the trench horizontal and level He shall also make level and hard the bed of all the trenches and consolidate the earth about the same and against all walls, pits, drains etc The foundation trenches to be inspected and passed by the Architects before any masonry work is commenced and the Contractor shall hold an order in writing to this effect, otherwise shall be liable to have his work removed for inspection The Contractor shall be responsible for all risks to life and property particularly during this operation

14 The Contractor shall afford the Architects every facility and give them adequate notice in the early stages of its preparation for inspection of all wood and iron work before it has received any coating of paint, also for inspecting any portion of the work whatsoever, either at the workshop where it is prepared, or upon the site at any time or stage of its preparation or execution

Filling in with Earth under Floors and Sides of Foundations and Plinth Walls.

15 To be done with good earth, or chips equally mixed with earth in 9" layers or as desired by the Architects and to be thoroughly watered and rammed and well consolidated so that the whole floor may be perfectly solid.

16 Portions found not to have been well consolidated to be rewatered and rammed until compact

Lime, Sand and Mortar

17. The lime to be of best quality burnt from approved limestone or kunkar

It shall be free from all unburnt pieces, ashes, cinders, salt or other impurities. All pieces of unburnt lime or other impurities to be screened out and removed before the lime is brought on the site

The lime shall be slaked on the site by 'drowning' or sprinkling according to whether it is a 'Fat Lime' or 'Hydraulic Lime' in such a manner and for such a period as may be approved by the Architects After slaking, the lime shall be screened and protected from air and moisture until required for use, but this period of storage of slaked lime shall be limited at the discretion of the Architects

All lime which has been damaged by rain, moisture, dirt or any other cause, and all slaked lime which has been damaged by exposure to air, moisture, dirt or any other cause shall be rejected and removed from the site of the work within 24 hours of its rejection

18. The sand must be from . . be clean, sharp and hard, free from large pebbles, salt, shells, earth, dust or other impurities If the Architects think it necessary, they may cause the sand to be screened, winnowed or washed with fresh water at the Contractor's expense

19 The mortar to be made of lime as specified above and clean sand and/or *soorkhi* approved of by the Architects and mixed in the proportion of one part of lime to two parts of sand or *Soorkhi* The lime and sand to be stacked before grinding in alternate layers of about 6" in depth and to remain uniformly when measured The materials to be then carefully mixed dry in small quantities and thrown into a *ghani* for grinding The grinding to be performed with a sufficient quantity of fresh water for such periods as may be ordered by the Architects (not less than 90 rounds) The mortar to be kept moist and well-sheltered from rain and sun till it is used in the work No mortar that has commenced to show signs of initial set is to be used in the work without the special permission of the Architects

Neeru

20 *Neeru* to be made of the best description of hydraulic lime slaked for at least one week by drowning with fresh water and sifted The lime to be reduced to a fine powder by grinding it on a stone or in a mill with a thick solution of '*mussala*' to be made as may be ordered by the Architects The *Neeru* thus prepared to be kept moist until used, and no more than can be consumed in 8 days to be prepared at a time

Lime Concrete of Stone metal kunker or over burnt brick bats,

21 The ground to be thoroughly levelled and well rammed before laying the concrete in the work The concrete shall consist (unless otherwise specified) of three parts of broken approved stone metal or other material approved of by the Architects and 1½ of mortar prepared as described under the head The metal and mortar to be stacked, before mixing The materials to be then thoroughly mixed in small quantities at a time with sufficient quantity of fresh water and laid in the work in layers each not exceeding 8" in depth, and repeated one above the other Each layer to be well rammed with heavy wooden or iron rammers The ramming operation to be continued until the cream of lime comes to the top and the whole work becomes solid and compact to the entire satisfaction of the Architects

22 The stone metal to be cubical and not flat chips and to be of good hard rubble stone from quarries to be approved of by the Architects The metal to be such as

to pass through a ring 1½ inch diameter Larger sized metal or chips will not be accepted The metal to be washed or screened before being stacked or incorporated with lime mortar

Un-Coursed Rubble Stone and Lime Masonry for Foundations, Plinth etc.

23 To be of the best description of rubble stone from quarries approved of by the Architects and lime mortar in a single course at a time not exceeding 12" in height The stones to be large, flat bedded and laid flush in mortar No stone to be less in breadth than 1½ times its height and less in length or tail into the work than twice its height Every stone whether large or small, must be set flush in mortar The small stones, used for wedging or filling in, to be carefully selected to fit roughly the space between large stones Care must be taken that no dry work or hollow space shall appear in the masonry work The stones to be arranged so as to break joints at least 3", and long vertical lines of joints to be carefully avoided everywhere The joints at the face to be finished off by being neatly struck and smoothed with a trowel while the mortar is fresh

24 One header or *Dhapa* in at least every five feet distance apart and at all junctions, returns, and angles shall bond into the work The header to be at least half a square foot in area at face and to run back at the entire width of the wall When the thickness of wall is more than two feet, a series of bond stones to be laid through the work so as to form a tie from front to back breaking joints or overlapping each other for at least 6." No stone whose length is less than 1½ feet to be used in the work as headers.

25 Quoin stones, flat bedded and of suitable size, to be provided at all angles, and bond stones having an excess of tail only in the wall and not of height, where required, to be also provided to insure uniform compactness of work All stones to be laid on their quarry bed.

26 Before commencing the masonry work the foundation trenches to be levelled right through and the bottom of the same watered and well rammed down The trenches to be kept free of water while the masonry work is in progress, or, if the Architects think it necessary, till the mortar used in the masonry is sufficiently set.

27 The masonry to be well watered until it becomes hard and solid and to be well covered during the rains Any work washed out by rain or other water to be removed and rebuilt at the contractor's expense

28 Mortar to be made as described under that head.

Cut Stone Steps.

29 The stone to be rectangular in shape, of hard and approved quality and colour and free from defects The stones to be *chisim* dressed on all exposed faces and set in fine mortar (neeroo) with close and true joints and a lap (and tail if required for side walls) of not less than 1½ inches The stones to be laid so as to break joints properly and to be well laid on the rubble masonry bedding in cement

30 The work to be covered with rough planking during the progress of work

Stone Khandki Facing (Coursed Rubble)

31 The Khandkis must be from the best size stones from quarry, of uniform colour, dressed to the Architects' direction There should be headers at 6'-0" distance No Khandki will be allowed to be used which is less than 6" in depth and dressed square 1½" wide at return faces

Brick Masonry Work in General.

32 The work to be built plumb, curved or battered, as may be required by the design, and to be carried out in a thoroughly workman-like manner and to the entire satisfaction of the Architects The contractors to provide at their own expense all moulds, templates, centres, scaffolding etc, as may be required for the proper execution of the work, which shall be included in the prices of the work, and no separate charge to be made for them

33 All bricks to be thoroughly cleaned and kept immersed for 8 hours in fresh water before being put into the work, and the mortar to be used stiff

34 The work to be kept wet while in progress to the entire satisfaction of the Architects till the lime is properly set On holidays or when the work is stopped the top of all unfinished masonry to be kept flooded and labourers to be employed for the purpose Watering to be done carefully so as not to wash the lime out of the joints The Architects shall be at liberty to employ labourers to water the work at Contractor's cost should the Contractors fail to do the same to their satisfaction

35 Should the mortar perish, that is, become dry, white or powdery through neglect of watering, the work shall be pulled down and rebuilt at the Contractors' expense

36 As a rule the whole of the masonry work in any structure to be carried up at one uniform level through-out, but where breaks are unavoidable the joint to be made in good long steps, so as to prevent cracks arising between the new and old work. All junctions of walls to be formed at the time the walls are being built and across walls to be carefully bonded into the main walls

37 When the new work is added to existing structure, the old work must be prepared to receive the new and both must be carefully bonded together

38 During the rains, the work to be carefully covered without extra charge, so as to avoid the fresh lime being washed away, and should any lime or mortar be washed away, the work to be removed and rebuilt at the Contractors' expense.

39 Where the word cement is used, it is to be understood Portland Cement of approved quality and best description Where cement mortar is stated it must be in porportion 1 part of cement and 4 parts of sand

Bricks and Brick-Work in General.

40 Bricks to be from kilns approved by the Architects and must be whole, sound, well burnt, free from cracks, to ring when struck and not to crack or break when soaked in water, regular in shape and uniform in size They should be of the best description obtainable in the market and of the best quality and colour, and in every respect to be approved of by the Architects Unless otherwise specified they should be of the English pattern 9"x4½"x3" No bricks to absorb water more than 1/5th of their own weight when dry Bricks to be thoroughly cleaned, well wetted and/or soaked

in fresh water, before being used on the work, and no broken bricks to be used except as closers

41. The mortar should be as described under that head, of good quality, carefully mixed and used stiff For joints of face work only *neeru* and screened sand should be used in equal proportions

42 A good bond should be preserved throughout the work both laterally and transversely All bed joints should be perpendicular to the pressure upon them, that is horizontal in vertical walls, radial in arches and at right angles to the slope in battering walls

48 In walling the courses shall be kept perfectly horizontal and the arises plumb The vertical joints shall break joints with the courses immediately below and above, but they shall be directly over one another in alternate courses to prevent the necessity of bats The joints shall not exceed $\frac{1}{4}$ inch in thickness, shall be full of mortar, close, well flushed up and neatly struck or pointed as may be required

44 English bond to be used throughout in walling In arching such bond shall be used as the Architects or their Assistant many direct

Arch-Work of Brick in Lime Mortar.

45 The arch to be turned in good,whole, well shaped, sound, hard bricks laid in concentric rings or otherwise as may be directed The voussoir joints to be properly summered or radiated to the centre of the curve and not to exceed T inch in Thickness where they are exposed to view or $\frac{1}{4}$ inch where the face is to be plastered The arches in face work to be of perfectly guauged bricks with neat, flat, ruled joints and pointed in *Neeru* or Portland Cement as directed The bricks forming skew back joints to be moulded or cut so as to radiate truly When the arches are built in concentric rings, great care to be taken that the rings are bounded together properly whenever the joints of any of the rings come to a summering The bricks to be well soaked in water before being used and laid flush in fine mortar made of *neeru* and screened sand in equal proportions The arches to be turned on proper and approved centres and the rate for arch work to include the cost of centres, setting up, easing and removing the same No centre to be eased or struck without the permission of the Architects, and if any arch settles unduly or becomes unsightly through the carelessness on the part of the Contractors, it shall be removed and rebuilt at the Contractors' expense If required the work to be finished off with mouldings, chamfers etc, as shown on the drawings

Reinforced Brick Partitions.

46 All Reinforced brick partitions to be built with sound, whole, well burnt moulded bricks laid in 4 1 cement mortar with the provision of suitable steel reinforcement in every fifth course to the approval of the Architects Reinforced concrete wall plates 8" deep will be provided as per Architects' decision

Chunam Plaster.

47 The joints between the stones or bricks to be raked out to a depth of $\frac{3}{4}$ inch at least so as to afford a good hold for the mortar The wall face to be then thoroughly washed and sufficiently wetted with fresh water until the old mortar in the wall

is wet The Mortar for the plaster to be made up of one part of lime and one part of fine sand and to be mixed with a sufficient quantity of "*Mussala*" water The mortar shall be ground twice at the interval of 48 hours The "*Mussala*" to consist of *jaghree*, *googal* and *catechu* or such other ingredients as the Architects may direct The first coat of mortar to be ⅜ inch over and above the filling of joints and rough cast, and the surface to be roughend as much as possible When this sets in sufficiently, the second coat of mortar properly gauged with screeds to be then applied in an even and uniform coat and to be wetted and well beaten with thapis and not allowed to show any cracks on the surface All moulding to be worked true to a template and drawn neat, clean and level All exposed angles and junctions with door frames etc, to be carefully finished When the second coat is sufficiently dry, the surface to be well watered and rubbed and a coating of *neeru* well ground to be applied,which should be well rubbed until the surface is smooth and even When it is half dried the surface to be watered and well rubbed and the finishing coat of "*Donga*' *i e* white wash to be laid which should also be rubbed wet until the surface becomes smooth The whole surface to receive three coats of powedered distemper.

Portland Cement Plaster.

48 The cement to be such as that described under the head of "Cement" and to be mixed with four parts of fine clean sand Sand to be washed in pipe water before mixing Rake out the joints and wet the surface as specified under "Chunam Platster to Walls etc" and apply the mixture about ½ inch thick evenly on the wall surface Leave the surface rough and apply a thin coat of pure Portland Cement and smooth off well The surface is not required to be beaten for this work The cement mortar to be used within one hour after it leaves the mixing board or mill

Coloured Cement Rendering

49 The first coat shall be ¾ inch thick consisting of rough approved sand and water proofed cement (1 4 proportion) screeded on the wall surface to form key to the second coat, The latter shall consist of Kharsalia sand and coloured cement of approved make and colour mixed in the proportion of 1 3 and applied ¼ inch thick and worked evenly obtaining grained surface The surface will be kept moist for at least one week

Sand-face (Smooth cast) plaster.

50 The first coat shall be ½ inch thick of rough clean sand and Portland Cement (1 4) evenly screeded to form a key to the second coat The latter shall be of *Kharsalia* sand and ordinary cement (1 3) and shall be applied ¼ inch thick evenly to bring out grained effect The surface shall be kept moist for at least one week.

Rubble Stone Pitching or Packing.

51 The ground shall first be watered and levelled up and then be well rammed by means of heavy rammers and thoroughly consolidated

52 Good hard stones shall then be laid and set with hand so compactly as to form a sort of dry rubble work.

53 After the rubble stones are well packed and set, a light roller shall be rolled over the surface or rammed with a rammer and the whole area well consolidated and levelled with the free use of water

54 Any hollows left in the pitching after consolidation shall be filled up with rubble chips and mortar at the Contractors' expense

Lime concrete for bedding of paving.

55. To consist of two parts of stone metal of one and a half inch gauge metal and one part of mortar, thoroughly mixed together and laid uniformly to be immediately rammed down, so as to cause it to be perfectly solid

56 The concrete bed not to be less than four inches in depth after consolidation and to be watered and kept moist until the mortar sets and the whole becomes solid mass

57 No concrete will be allowed to be mixed on the ground or road, but all concrete depots shall be laid on specially constructed wooden or iron-plate platforms or boxes

Polished Flag Stone-Flooring and Sills.

58. The surface over which the pavement or sill is to be laid shall be levelled up and closely picked so as to form a good key-hold for the cement bedding or rendering and shall be thoroughly saturated with water

59 Mortar bedding made of lime mortar (1 1½) shall be gauged and spread not exceeding 1 inch in thickness as bedding to receive the stone slabs for flooring or sills

60. The stones to be laid either diagonally or in squares as per Architects instructions without any joint beaking, the joints of both to be full flush in mortar and set with good Portland Cement and hard tapped with wooden mallets, all joints being full and flush with cement, and stones and sills shall be fine sand polished where ordered by the Architects

61. The stones used for this purpose shall be of uniform thickness of 1" to 1½"

62 All stones to be even and smooth no pitted, chipped, uneven, concave or convex surfaces to be allowed

63 The entire flooring and sills to be up to the Architects design

64 On completion of work the whole surface shall be cleaned of all dirt, mortar and cement daubs and sprinkling and to be thoroughly and cleanly washed

Door and Window Frames.

65 To be solid, of best Moulmein teak of approved quality and mark and of such scantlings as may be shown on the drawings, specified in the specification or as may be ordered by the Architects

66 To be properly framed and morticed together and set solidly in the masonry The parts hidden by masonry to be well tarred with boiling coal tar or oil painted two coats as may be directed by the Architects

67 The frames to be rebated on one side ½ inch wide, if there is to be a single door, and of the full thickness of the shutter and to have a return bead or moulding on the other side as may be directed, or rebated on both sides, if there are shutters on both sides

68 The frames of doors and windows to be included in the rates of doors and windows, unless otherwise specified, and the rates to include supplying and building in teak wood fixing blocks of approved number and dimensions in masonry jambs where door and windows are to be fitted as the work proceeds, and also all cost of providing cutstone or concrete templates to fix and rest the vertical door framings

69 All the necessary cover-moulds at junctions of door and window frames and masonry or cut-stone work to be included in the rate of door and window frames or in the rates for door and window shutters where there is an inclusive rate of shutters and frames

70 Each door shall be provided with three pairs of brass hinges, parliamentary or both as the case may be, two eight or six inches brass or oxidised brass bolts at the bottom, two 12" at the top, properly fitted with sockets or angle plates, two brass hooks complete with brass screws Two brass oxidised or chromium plated handles to be selects ed hereafter, to be provided for and fixed All brass fixtures, fastenings and fittings to be included in the rate

Doors Pannelled.

71 To be of the best Moulmein teak of approved mark and quality

72 The frame to be of the sizes specified in the schedule of rates and morticed together in a workmanlike manner.

73 The styles and top, bottom and frieze rails to be struck or planted, moulded on both sides to detail and to be of such widths as may be ordered by the Architects

74 Each panel to be in one plank tongued to styles and rails

75 Each leaf to be hung with three brass butt (or back flap) hinges 4 inche long with brass screws (if necessary) Each leaf to have two brass or oxidised bras flush or barrel bolts of such lengths as the Architects may direct Doors and windows without a lock shall also have a good approved handle Usually the tower bolt to a door or window to be at least 6 inches in length and the top bolt to be of 12 inches in length

76 The fixtures and fastenings to be all of polished brass oxidised or chromium plated of the best make and to be of sizes approved or ordered by the Architects

77 All doors and windows including frames to be painted in three coats of oil paint of such colour as may be directed or at the discretion of the Architects, or varnished with best degrah or valspar or other approved varnish in three coats

78. All dimensions shown on drawing or stated in the specification to be finished sizes in all cases

N.B. All fixtures and fastening to be of approved make Wherever brass fixtures or fastenings are specified the screws to be used for the fixing of same shall be brass For windows catches to be supplied and fixed, and for doors all-drops wherever pointed out by the Architects

Doors Partly Panelled and Partly Glazed or Partly Panelled and Partly Venetianed.

79. To be similar in all respects to previous specification except the following —

(a) In the case of glazed doors, such parts to be glazed as may be directed by the Architects or shown on the drawings with sheet glass $\frac{1}{8}$ inch thick and like manner in the venetianed doors such parts to be filled in with venetains as may be directed

(b) Styles and rails in glazed portions to be rebated ½ inch wide on the one side or two sides to receive glass

(c) The glass to be used should be as specified under Glazier's work

Doors and Windows Glazed.

80. To be as per specification for panelled doors, with the exception of the panelled portion, which should be glazed.

81 Fixtures and fastenings are to be of oxidised brass of approved quality make and dimensions.

82. Fan lights of doors and windows will have proper closing arrangements of approved design.

83 The glass to be used to be 1/8th inch thick English 26 oz sheet glass, unless otherwise specified.

84 Each window shall have two pairs of 3 inches hinges, two handles, two tower bolts and two eyes and hooks—all of approved material and design

Cement concrete plain and reinforced.

(A) All reinforced concrete work shall be designed and working drawings and details shall be prepared by a Consulting Engineer to be approved by the Architects, whose fees will have to be paid by the Contractor

(B) All floors will be designed for super loads to be specified by the Architects. Design of the R C C work must be in Conformity with the London County Council regulations latest edition and approved by the municipal authority and Architects.

Cement.

85 Portland cement to be obtained from approved Indian Manufacturers and shall conform in every respect to the British Standard Specification for the time being in force, quick setting cement shall not be used without permission from the Architects in writing

86 Cement to be delivered in sound and properly secured bags, barrels or other packages ready for immediate use and to be used direct from bag or barrel.

87. The cement shall be kept in a perfectly water tight and otherwise suitable store, the wooden floor of which shall be raised not less than 6″ from the ground The Contractor shall maintain sufficient stock of cement to ensure continuity of the work, and each consignment shall be so stacked separately as to permit of easy access for inspection

Fine Aggregate.

88 The fine aggregate shall consist of hard silicious sand, crushed stone or other material approved by the Architects It shall be clean and free from clay, and any salt, animal, vegetable, or other deleterious matter All fine aggregates shall be thoroughly washed with clean water if desired by the Architects

89. All fine aggregates shall be capable of passing through a mesh 3/16 th of an inch square measured in the clear, and not more than 10 per cent shall pass through a sieve having 40 meshes to the linear inch and wire of 0 0125 inch in diameter, and it shall be well graded between these limits

Coarse Aggregate.

90 The coarse aggregate shall consist of broken stone or similar material as directed and approved by the Architects

91 The coarse material shall be of such size as will pass through a mesh of three quarters of an inch square and shall be retained on a mesh three sixteenth inch square and shall vary as much as possible between these limits

92 The coarse aggregate shall be thoroughly washed with clean water if so desired by the Architects.

Proportions.

93 The concrete shall be composed of Portland cement, fine aggregate, and coarse aggregate The proportion of cement shall be measured by weight, and that of the fine aggregate and coarse aggregate shall be measured separately by volume

94 The proportion shall be 1 cwt of cement to 2½ cu ft of fine aggregate to 5 cu ft of coarse aggregate (*i e* 1 2 4 mix) unless otherwise specified by the Architects

95 All the fine and coarse aggregates shall be gauged in the required proportions and in such manner as shall be approved by the architects.

Water.

96 The water used for mixing cement grout, mortar, and concrete shall be free from earthy, vegetable or organic matter, acids and alkline substances in solution or suspension

97 The consistency of the concrete shall be determined from time to time as the work progresses by slump test The amount of slump and tolerance shall be as agreed between the architects and the Contractors.

Mixing.

98 Machine mixing shall be done by power driven batch mixers of approved type The concrete shall be mixed for not less than two minutes, and until it is of even colour and of uniform consistency throughout Any concrete which shows signs of initial setting before it is deposited, shall not be used in the work and shall be at once removed from the site

The water for each batch of concrete shall be measured in a suitable tank provided with a means of adjustment for the proper amount of water used for each charge

The concrete shall be discharged from the mixer on to a level water-tight platform or floor or into a water-tight receptacle.

99. The Architects may permit hand mixing and in such cases the mixing shall be done on a hard, clean, impervious and even surface of adequate size and properly supported

The material shall be mixed as follows :—

(*a*) The measured coarse aggregate shall be spread to an even level

(*b*) The measured fine aggregate shall be spread evenly over the coarse ag gregate

(*c*) The requisite quantity of cement shall be spread evenly over the layer of fine and coarse aggregate

(*d*) All the ingredients shall be turned over dry three times or more until they present an even colour throughout

(*e*) A measured and sufficient quantity of water shall then be added through a rose while the ingredients are being turned over three times or more in the wet state, long pronged rakes being used if required

(*f*) The consistency of all batches of concrete shall be uniform

Reinforcement.

100 All mild steel reinforcement shall comply with the conditions and tests laid down for class "A" steel in the B S S No 15, for structural steel for bridges, and general building connection, or such revisions thereof as may from time to time be published Rerolled old material shall not be permitted to be used

101 Material which is found to have developed brittleness, cracks or other imperfections or which is found not to comply with the specified tests requirements shall be rejected and shall be removed from the work within three days of an order from the Architects

102 All reinforcement when placed in position shall be of the sectional area specified and as shown in the detailed drawings.

103 All reinforcement shall, before depositing the concrete, be free and clean from all loose mill scale, dust and loose rust and coatings such as paint, oil, etc

104 Welding shall not be allowed in any main reinforcements.

105 Bends, cranks and other labours on metal reinforcements shall be carefully formed, otherwise all bars shall be truly straight Bends shall be made cold round a pin having a diameter of at least four times the diameter of the bar

106 Bars above 1½ in diameter may be bent at a cherry red heat but the bend shall not be cooled by water or any other liquid

107 Bars to be helically wound shall be coiled in long lengths and when necessary joints shall be made according to details approved. These joints shall not occur at places where the deposition of the concrete has been temporarily discontinued

108 The number, size, form and position of all steel mesh work bars, ties, links, stirrups and other parts of the reinforcement shall be placed in exact position in accordance with the working drawing Nothing shall be allowed to interfere with the required deposition of the reinforcement, and the Contractor shall make it a particular point of seeing that all parts of the reinforcement are placed correctly in every respect and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place The longitudinal bars of struts, pillars, and piles, shall be straight and fixed parallel to each other and to the sides of the forms The ties, stirrups or link connecting the bars shall be taut so that the bars are properly braced, the inside of their curved parts shall be in actual contact with the bars around which they are intended to fit

109 Bars shall be bound together with pliable iron wire, or other approved form of binding where directed, so that the reinforcement may not be displaced in the process of depositing the concrete

Wire for binding shall be thoroughly annealed soft iron No 16 B W G and the binding shall be done tightly with proper pliers

110 Metal reinforcement left exposed to the weather for eventual bonding with future extensions shall be protected from corrosion

Formwork.

111 The Contractor shall be responsible for the sufficiency of the formwork, but if required by the Architects he shall before commencing work submit for approval details of the formwork to be used

112 All formwork shall be securely braced and supported to prevent any sagging or bulging during the construction All forms, shall be fixed to proper grade and turned up immediately before depositing concrete

113 All joints shall be close enough to prevent leakage of liquid from the concrete

114 The formwork shall be so arranged as to permit of easing and removal without jarring the concrete Wedges, clamps and bolts shall be used wherever practicable for securing the true position of the forms

115 Unless otherwise specified all timber formwork for beams, columns and the like should be wrought at least on the concrete face and thicknessed, with edges shot and close joints Steel plate forms without angle iron frame for slabs shall not be permitted to be used

116 Care shall be taken that when any formwork is re-used, its surfaces shall be even and clean

117 Concrete sloping at an angle exceeding 30 degs with the horizontal shall be shuttered on the upper surface

118 The bottoms of beams shall be cambered when necessary or when required by the Architects

119 Formwork or moulds for beams and allied members shall where so required be designed and supported in such a manner that the sides may be removed without interference with the remainder of the formwork

120 The supporting struts shall be adjusted and fixed in position by suitable means They shall be placed upon proper sole plates and so arranged that they may be released or lowered gently before or at the time of final striking

121 Unless otherwise authorised by the Architects all moulds for rectangular columns shall be designed and constructed with one side open from bottom to top and open side shall be filled in as successive layers of concrete are placed and tamped into position

122 The responsibility of the safe removal of the whole or any part of the formwork shall rest entirely with the Contractor

123 The period which is to elapse between the complete filling of concrete into the forms and the releasing or removal of such forms will vary with the particular design of the structure or member and other conditions, and where the Architect specifies a minimum period such period shall not be reduced, but whether a minimum time is specified or not, the full responsibility of releasing or removing formwork of all descriptions shall devolve on the Contractor

Concreting

124 Immediately before any concreting is commenced all formwork shall be carefully examined to see that all dirt, shavings, sawdust and/or other refuse has been removed by brushing and/or washing with a hose All traps and temporary doors shall be carefully made good before any concrete is put into place

125 The inside of the forms should be treated with a coat of approved material if so desired. The inside of the moulds should be wetted shortly before concreting is commenced

126 All concreting shall be done as quickly and efficiently as possible to the satisfaction of the Architects

127 The concrete shall be conveyed from the mixer to its place as rapidly as possible and in such manner that there shall be no separation or loss of the ingredients It shall be deposited in the forms as nearly as practicable to its final position

128 The use of concrete distributing shoots at an angle of more than 45 degs from the horizontal shall not be permitted unless specially agreed to in writing by the Architects.

129 Unless a vibrator is specified for use, the concrete shall be sufficiently tamped and consolidated round the steel reinforcement and into all parts of the formwork Care shall be taken that the steel reinforcement is thoroughly surrounded by the concrete and that no voids or cavities are left Care shall be taken that the reinforcement bars projecting from concrete which has been recently put into position shall not be shaken or disturbed

130 Before executing reinforced concrete work in foundations any moist or soft ground shall be excavated to a further depth of three inches and layer of rough concrete 1 cwt cement, 5 cubic feet fine aggregate, 10 cubic feet coarse aggregate shall be spread and levelled by spade finish, or dealt with otherwise as the Architects may direct

131. The work shall be concreted in layers of thickness sufficient to ensure proper tamping and the full thickness shall be made up in immediate consecutive similar operations

132 Where cessation of work is essential or unavoidable, the break shall be as directed by the Architects The joints of new concrete shall be squared to the main reinforcement

The ribs of L or T beams, if separately concreted from the slab, shall stop no less than one inch below the soffit of the slab Similarly the concreting of columns shall stop not less than one inch below the lowest portion of any connection at point of junction with column

133 Before depositing fresh concrete upon or against any concrete which had already hardened, the surface of the hardened concrete shall be thoroughly roughened thoroughly cleaned from all loose and foreign matter and well washed with clean water Before the concreting is commenced, the hardened surface shall be covered with mortar composed of one part of cement to five parts of fine sand, about half an inch thick Special care shall be taken to ram the mortar and fresh concrete thoroughly up against the hardened concrete

134 Reinforcement shall in all cases be covered with not less than the minimum thickness of concrete specified or shown on the drawings.

135 The surface shall be kept moist as long as may be directed by the Architects The work shall be protected, where practicable, from the direct rays of the sun and from drying winds

136 Once concrete is laid in forms care shall be taken that no shock or vibration shall reach the concrete during the process of setting and preliminary hardening

137 The faces of the concrete work shall be left sound and solid, free from voids and excrescences No "patching" of any concrete facing shall be carried out without the express permission of the Architects

138 Surfaces to be decorated in plaster or otherwise, shall be left or made rough to form a key where required

Fittings and Accessories

139 Holes for bolts or for any other purposes shall be moulded during the work of concreting in the positions shown on the drawings Openings to receive pipes, wires and other fittings shall be formed where shown or otherwise detailed

140 Bolts, pipe hooks, hangers and other connections and fittings shown on the drawings or as directed by the Architects shall, as far as practicable, be built in as the work proceeds.

141 Pipes for the conveyence of steam, water and gas and for the reception of electric cables and wires, shall be carried along the exterior of the concrete work, except where openings or ducts in which the pipes, cables and wires can be fixed after completion of the concrete work have been formed or where provision is made in the drawings for the pipes to be embedded

Tests on Completed Work

142 After ample time has been allowed for the hardening of the concrete, loading tests on the completed structure shall be conducted on portions to be selected and in manner as directed, by the Architects, if they so desire, without any extra charges whatsoever

143 All loading tests shall be conducted by the Contractor under the direction of the Architects Unless otherwise specified the Contractor shall provide all instruments apparatus, material, labour and assistants necessary for the proper execution of the tests.

144 Not more than the superimposed load for which the work has been designed plus 50 per cent shall be applied as a test load

145 When dead loads are applied for testing, the material used for loading shall be put on in such a manner that no arching action whatever can take place within it

Slabs, Beams and Columns

146 These shall be as per the drawings and details prepared by the R C C Designer but the Architects shall have the full power of making any changes in the designs for architectural or other reasons The shapes and sizes of columns and beams may be altered at any time during the progress of the work if the Architects so desire for architectural reasons and the contractor shall be bound to carry out these changes without any extra charge whatsoever The rate shall include all simple mouldings that may have to be carried out in the centering work itself

Reinforced Concrete Staircases.

147. To be built to design with reinforcement as shown in the detailed drawings The work to be as per specification (Reinforced Concrete work) The dowel bars as per detailed drawings shall be provided for R C C parapet wall or necessary holes for fixing the railing shall be neatly cast

148 The railing to be of 3" R C C parapet wall with W I Railing as per design with teak hand rail to detail The W I Railing will have three coats of aluminium or other approved paint including one coat of anticorrosive paint The handrail will have French polish as per instructions

149 The staircase shall be paved with 1½" teak treads and 1½" teak riser Teak wood will have three coats of oil paint or copal varnish of approved quality and make

150 All newal posts to be fixed and carried out to design The rate for the various staircases shall include all items requisite for the due completion and finish of the same, as per details to be supplied by the Architects

151 All landings to be included in the rate of staircase, each landing being considered as equivalent to two steps or treads All beams and cantilevers needed for supporting staircases shall be included in the rate per tread of the staircase.

Painter's Work.

152 When painting on wood, work shall first be cleaned, all such projections as glue or whiting spots being carefully removed with the stopping knife and duster, after which all knots shall be killed with one or more layers of oil and white lead or red lead and size or glue laid on warm and rubbed down when dry with sand paper or pumice stone

153 The surface shall be thoroughly dry before the priming coat is applied

154 The work shall then be primed with a coat of four parts by weight of lead mixed with one part of twice boiled linseed oil

155 In woodwork, all holes, cracks and nail heads shall then be stopped with putty and irregularities reduced with sand paper and pumice stone

156 Iron work shall be first thoroughly cleaned from rust and dirt, after which red lead alone shall be used as priming

157 For other materials when the work is to be finished in a dark colour, the priming may be lead colour, if to be finished orange, red and similar tints, the priming may be pink

158 All colours to be laid on evenly and properly with best approved brushes

159 Each coat of colour to be allowed to dry thoroughly before the next is laid on, and all except the last coat to be slightly rubbed down with pumice stone

160 No hair marks from the brush shall be left on the work, or puddles in the corners of panels, angles of mouldings etc

161 White paint to be made of the best mineral white Hubbuck's or other approved paint and Blundell double boiled linseed oil, properly ground and mixed together with small quantity of turpentine

162 Linseed oil used shall be of Blundell and Spence's pale and brilliant, mellow and sweet to the taste with very little smell and shall be boiled twice When country linseed oil is permitted to be used, it should be boiled for two or three hours with red lead and litharge in the proportion of one pound of each to a gallon of oil

163 Putty shall be made as specified under Glazier's work

164 When tinted colours are required a small quantity of the proper tint should be first prepared to serve as a guide by which to mix the whole quantity. The ground whitelead shall first be well mixed with a portion of the oil, and then the tinting colour shall be added to match the pattern and thoroughly mixed, after which the remaining portion of the oil of turpentine is to be added, and the whole passed through fine canvas or a fine sieve The consistency shall be that of cream so as to work easily

165 Varnish to be either Degrah or Valspar or such other make as may be specified by the Architects

166 Wood oiling, when employed as a substitute for painting timber work, to be of linseed oil with a small quantity of dammer boiled up with it or red ochre

Varnishing

167 The woodwork to be varnished when cleaned and rubbed down to receive two coats of clean boiled linseed oil or two coats of size laid on at sufficient intervals of time When dry the varnish is to be smoothly laid on in thin coats The varnish to be of best English Varnish of approved manufacture

White Glazed Tile Dados.

168 The walls to have the best glazed tiles with concave and convex corner tiles of approved make with 3 inches top border tile to heights determined by the Architects

Colour Wash.

169 The internal walls to be covered with three coats of colour wash over one coat of priming The colour wash used to be in selected colours and approved make and the coating to be smoothly laid on in the manner directed by the makers

Glazier's Work

170 The glass, when not specified, to be sheet glass of the best quality weighing 20 oz to the foot specified

171 All glass to be free from specks, blisters and all other defects and where no wooden mouldings are to be used to be set in good putty and the rebate neatly chamfered

172 All putty for the purpose to be made of best whiting and oil, the whiting to be specially dry and passed through a sieve of 45 meshes to the inch and to be mixed with as much linseed oil as will form it into a stiff paste This, after being well kneaded, shall be left for 12 hours and worked up in small pieces till quite smooth If the putty becomes dry, it should be restored by heating and working it up again while hot The putty to be coloured to suit the colour of the door or window

173 All glass to be cut to fit the rebates of the sashes truly

174 All glass to be properly bedded, puttied and back puttied and pinned to the frame with brads and finished in a workmanlike manner

175 No glazing to be complete until all stains and marks have been removed from the surface of the glass and wood

176 All glass panes shall, if they become loose during one year, be refixed and reputtied by the Contractors without extra charge

177 The Contractors shall make good without extra charge any glass broken before the completion of the work

178. When sheet glass is specified it should be of the best quality of "British Sheet Glass" weighing not less than 26 ozs to the square foot

179 All the windows shall be cleaned, all damaged putty or glazing shall be repaired and the whole left perfect on the completion and rendering up of the work

Drainage.

180 Burns or Jubbulpore or other approved make Salt-glazed stoneware pipe 4" diameter for branches and 6" diameter for main drain shall be used on a bed of lime concrete 6" thick and will be jointed with 1 1 sand and Portland Cement mortar by first inserting one ring of fine hemp immersed in coal tar, and finished off with neat cement The trenches shall be filled in by one foot layers of excavated earth well watered and tamped. At every curve and change of direction and junctions there shall be constructed an inspection chamber of sizes specified by the Architects in brick in cement masonry 9" thick walls all round, the same plastered in cement mortar rough outside and neat cement rendered inside, and shall have a C I frame and cover with water seal The chambers shall be constructed on a six inch lime concrete foundation and the bottom finished off with a half round central channel and branches in cement concrete One S. W sewer trap with a cleaning arm shall be provided at the end chamber Two C. I vent pipes one at the head of the drain and another at the end chamber shall be provided and shall be carried to a height of fifteen feet above all buildings within forty feet radius One storm water gully trap be provided at the lowest position in the compound and shall be connected with the Municipal Storm Water Drain in the Road Drainage passing inside the building shall be in C I Spigot and socketed pipes with lead caulked joints laid on lime Concrete bedding

Water Closets and Bath Rooms.

181 Water closets shall be in white glazed vitrious chinaware Indian type approved by the Architects, 27" overall in length and shall include a P or S trap of the same material. The closet and trap shall be encased in a fine mixture of brick bat and cement concrete Shank's mosquito proof "Reliable" Cisterns or other of approved make shall be used and shall have 1¾" leadflush pipe and ½" lead overflow and service pipes with all necessary solder wiped joints and brass plumbers unions and ½" brass stop cock on service pipe. All joints with the water closets shall be made of equal parts of white and red lead mixed with chopped hemp and boiled linseed oil The outlet to the water closets shall be on the upper floors of 4" solid drawn lead pipe bent to proper shape, weight of pipes 7 lbs per rft with heavy brass thimbles and tailpieces and tin and lead solder joints and screwed cleaning caps The W Cs shall be connected to soil pipes 4" diameter and 2½" C I Anti-siphon pipes with necessary lead pipes shall be provided to each W C C I nahani traps of 3" outlets shall be used in each *naham* shall have sufficiently long bend to keep the joints outside the main wall and shall be connected to 3" C I Waste pipes with necessary ventilating outlets All vent pipes shall have at top copper baloon wire domes All C I pipes and fittings shall bear the marks "E I C" All waste pipes shall discharge over disconnecting S W Gully traps fixed in masonry chambers with C I frames and covers of full size

Water Supply

182 The water supply pipes shall be laid of such diameter as will be decided by the Municipality The pipes shall be W I galvanized and shall bear the test mark stamped by the Municipality if possible From the rising main separate independent branches of the same diameter shall be taken to all upper floors and the ground floor only ½" diameter branches Downtake pipes shall be in any case of 1" diameter with brass stop cocks for control at the head. ¾" taps for the ground and first floor shall be used All brass stop cocks bibcocks and babcocks shall bear the stamp J C S W R" The storage cisterns shall be of Galvanized L Plates 1/8" thick well rivetted on to G I Angle iron frames and caulked and shall have a Municipal patterns, Mosquito-proof hinged C I Round frame and cover Heavy tested stop cocks shall be provided on all the inlet and outlet pipes All cisterns shall have a cleaning outlet with plug A brass ball cock with copper float shall be provided in each cistern. The cisterns shall be made perfectly mosquito-proof and placed on R. S Beams at least 9" above the floor supported on concrete blocks

183 All Drainage and plumbing work shall strictly be in accordance with the Municipal Rules and Regulations and conform to the Municipal Bye-laws and also P W. D Hand book Specification latest edition, and be carried out through the agency of a Licensed Plumber and Completion Certificate obtained from the Municipality

WHETHER BY CONTRACT AGENCY OR ON DAILY WAGES.

Whether the work is to be got done by contract or on daily wages is a matter to be decided by the owner himself The latter may be tried only if the owner himself has some knowledge of the fundamentals of construction and further, if he has a competent *mistry* thoroughly acquainted with construction and local conditions whom he can safely trust.

Each system has its own advantages as well as disadvantages. If the contractor is a conscientious man, the contract system is of course the best, as it is the cheapest, and leaves the owner free from the worries inseparably concommitant with building operations. But it is very difficult in these days to find a really conscientious and trustworthy contractor. It is such a business as does not require any special qualifications on the part of the man entering it. A strong common sense, a good knowledge of human psychology and experience in building construction is all that is required. Thus you will find people of all grades, from university graduates down to illiterate carpenters or masons, taking themselves to this profession. Not only this, but educated men who have some position at stake cannot stand in competition with the other class of contractors. As a matter of fact, some of the latter quote obviously impracticable rates.

Such people who have an eye only to the ultimate profit without any regard to the quality of work, have a tendency to use bad or inferior material and finish the work somehow, haphazardly and in haste. Further, the contractors on their part usually supply materials themselves and sublet contracts of the labour part to different tradesmen, e g. all excavation and filling to excavators, concreting to another batch of labourers, masonry to a mason, all wood work to a carpenter etc. etc., leaving sufficient margin of profit in each item, for themselves. These sub-contractors have a tendency to finish

the work somehow and pocket the money. Hence, unless the contractor is very particular in exacting the work properly from everybody concerned innumerable flaws are

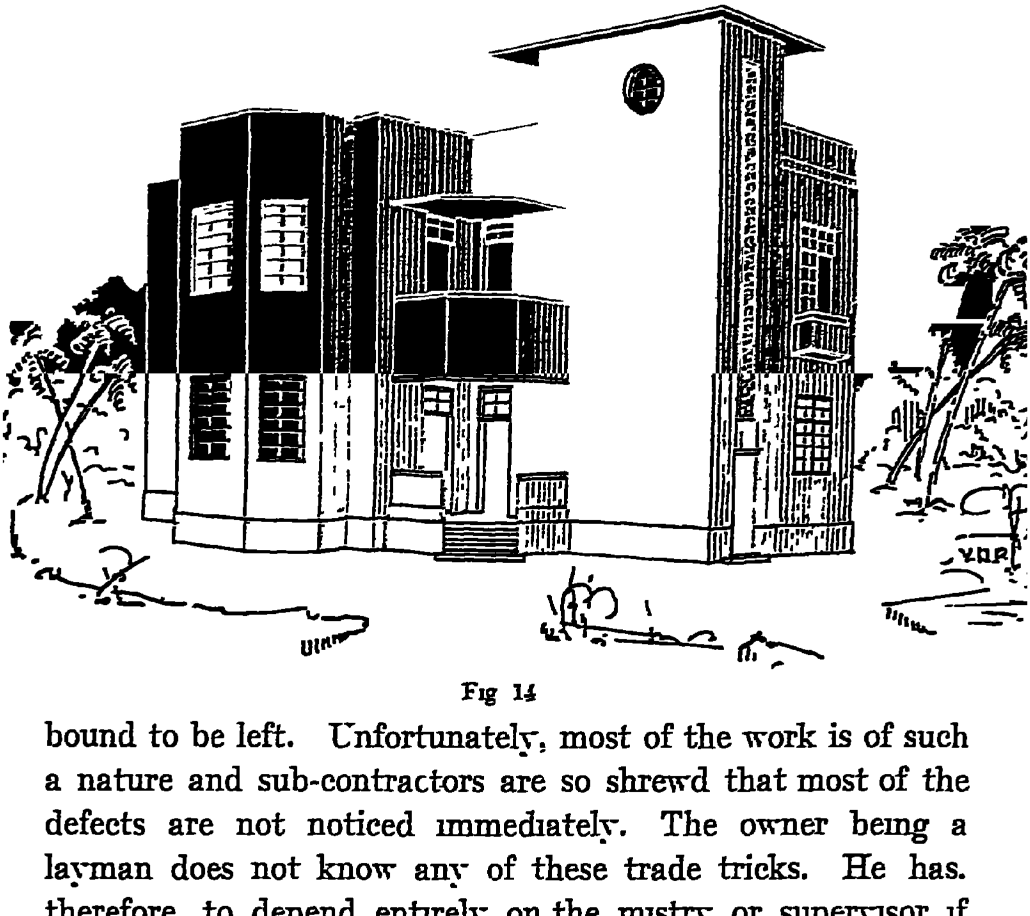

Fig 14

bound to be left. Unfortunately, most of the work is of such a nature and sub-contractors are so shrewd that most of the defects are not noticed immediately. The owner being a layman does not know any of these trade tricks. He has, therefore, to depend entirely on the mistry or supervisor if he cares to appoint one to supervise the contractor's work. Sometimes the mistry may also be bribed by the contractor. In that case the position becomes still worse. For, the mistry receives payment from you and secretly works in the interest of the contractor.

When tenders for work are received from contractors, you will be surprised to find some contractors offering to put up your house for Rs. 2,000/- less than the estimated cost.

If you find such cheap contractors you can be sure that he intends to give you bad material and bad workmanship. You must avoid such people. Taking advantage of lack of technical knowledge on your part, they might use lime which is stale or adulterated with white clay, put too much sand in it, stint on grinding it propely, use less mortar in concrete, put thick layers of the latter in foundation to save labour in ramming it hard and so on. He can substitute cheaper ingredients for more expensive ones, leave hollows in stone walls, use "green" *i.e.*, unseasoned timber which subsequently shrinks and opens cracks, use less steel and cement than specified, in reinforced concrete work and so on. Though he gives a written guarantee to remove whatever defects may be discovered within a certain period after completion of the work, it is not worth much. For, such defects are apparent only after a year or two, after the expiry of the period of his guarantee, and after you have already paid him in full. You might then notice to your great chagrin that the walls are cracked, that the floors have settled, that the roof is leaking, paints peeling, door and window shutters jamming, joints in plumbing work leaking, and it is only then that you feel sorry to have saved Rs. 2,000/- initially, and to require twice as much more now to set the defects right. Further, this patchwork is never so satisfactory as original good work.

The ways of some other contractors are slightly different. They first quote low rates and subsequently take undue advantage of your tendency to make alteration in the original ideas. If you have provided for wooden ceiling in your original estimate and now want to adopt ceiling of asbestos cement sheets, because the latter is lighter, has less number of joints and looks better, though it may cost the same thing as teak ceiling or even less, the contractor will quote a rate 50 per cent. in excess on this 'extra' item and you cannot

bring in another contractor to do only this small bit of work, and thus, at least out of policy you have to yield though with a secret murmur at heart. Very often contractors continue to create an impression in your mind that the work will not cost much and afterwards cause you a surprise by quoting unexpected high rates.

If your architect is a man having considerable building experience to his credit, his estimate will serve as a very useful guide in selecting a proper contractor. Reputable contractors, who mean to do a good job of work usually come within a few hundred rupees of each other. Select one amongst such as put up figures approximating to your acrchitect's estimate—one who has good references of work done before. See his testimonials, make confidential enquiries with his previous employers, particularly as to whether he is a man of compromising nature and then decide to give him the work. This is more important, if you are a Government servant and cannot afford time to go to law or at least want to shun it as far as possible. If his quotations are slightly higher, discuss the matter with him. He will usually be prepared to cut it down, or at least suggest to you some means of reducing it. After all he won't lose the work for the sake of a hundred rupees or so

If you are lucky in finding such a realiable contractor then all your troubles will end and you will be very happy. Once the work is entrusted to such a man trust him fully unless you find a positive proof against him. It is human nature to look with suspicion on a contractor's work. Some people are prone to invite visitors, laymen or otherwise, and ask every one of them to comment on the work. Some of them, without knowing much, exaggerate the importance of small defects, just to show themselves off. This only serves to create a misunderstanding between you and the contractor. Key to success is to maintain good, smooth relations mutually.

If you entertain any doubts any time, express them tactfully to the contractor and in nine cases out of ten you will find. if he really be a conscientious man, that he will furnish satisfactory explanation or set the matters right

If, on the other hand, you want to get work done on daily wages, there is absolutely a necessity of employing a competent mistry. He will help you both in the collection of labour and material and also in supervising construction. If the mistry is a man of the proper type, you may be sure about the good quality of work, but it is bound to be costly. The contractor is on the other hand, a man highly trained in his art, he best knows the market from which to buy his materials and has already established his credit in it. He has the best artisans and labourers at his command and also all the necessary equipment, he knows what outturn of task-work may be expected from an artisan in a day and thus he is capable of getting work done most economically on account of efficient organization. In short he applies something of the method of mass production.

The conditions are just the reverse when you seek to get the work done on daily wages. You have every disability to face. Furthermore, the people engaged in the building trade such as *wadars* (stone breakers, who are aboriginals). unskilled labourers, carpenters, masons, smiths, etc. come mostly from the lower classes, uneducated and uncultured. They take undue advantage both of your ignorance and leniency and try to deceive you. Dealing with such people is a difficult thing. Sometimes, they make unreasonable demands for money and if you are not prepared to satisfy them, they threaten to strike work and if they actually do so the whole building operation temporarily comes to a standstill.

Another difficulty for work carried on daily wages is in respect of certain equipment, such as mortar mill. mixing

platform, scaffolding material, water cistern, sieves, wooden boards for the centering of reinforced concrete work etc. The contractor purchases all this once for all and uses it on different works over and over again. An individual cannot always get it on a reasonable hire and if he purchases it newly, after its being used only once, on his work, it fetches very little value when sold. Thus, this system, though it ensures good quality of work is both uneconomical and is beset with a number of difficulties.

There is a third system intermediate between these two which possesses most of the advantages of both these with only a few disadvantages. In it a competent and reliable mistry is essential. In it the owner purchases all the materials with the help of the mistry and the construction is done by giving contracts of labour to different foremen of each trade by calling for tenders and approving suitable ones from amongst them. Thus the tender for carpentary may contain all the items of labour involved in building construction and that for masonry all the work which a mason usually does, such as stone masonry, brick masonry, plaster, paving, etc. etc.

In this system since the materials are supplied by you they will be of the best quality and the mistry's business is to see that the work is being done in a proper manner. Since you have to pay for the labour at fixed rates, all the responsibility of getting it done economically and also collecting labour and dealing with them rests with the different foremen. In short, you eliminate the middleman's profit in this. The foremen usually do the work with their own hands with the help of a few hired fellow workers and are satisfied if they earn only a little more liberal wage for themselves. Thus, both the good quality of work and economy may be ensured.

However, to avoid possible troubles it is advisable to take certain precautions from the beginning if this system is to be adopted. They are :—

(1) In no event should any sums be advanced to the foremen. If you do it once they will give you endless trouble by making frequent demands at irregular hours. Further, there is a possibility that the money may be spent away by them soon after you give it, in either sweets or drinks and when the time comes for paying the wages of the labourers employed by them they have nothing left with them. The safest way is to take detailed measurements of work once a week, prepare the bill and distribute the wages of the labourers yourself in the presence of the foremen and pay the balance to the latter.

(2) As a precaution the mistry should keep an attendance roll of the workmen employed, so that if any point of difference arises, you have some basis of information as to the approximate dues of the foreman. This will also serve as a check on the bill prepared from the measurements of work.

(3) Implicit reliance should not be placed in the foremen in respect of certain minor items, which cost very little but are very important from the point of view of the strength of the work *e.g.*

(*a*) ramming concrete in foundation, even though the foreman who lays concrete is expected to do this, it is better to employ one or two coolies for a day or two at your own expense to ram it in addition ;

(*b*) watering masonry ; though the mason foreman is expected to sprinkle water on masonry, do not entirely rely on him. It is worth spending some more money and to get this job done satisfactorily by your man, because, if it is haphazardly done by the

foreman the strength of the masonry is likely to be adversely affected, and so on.

(f) A time limit for finishing the work should be specified within which the mistry must get the work completed. In the absence of this he might have a tendency to keep it lingering just to prolong the period of his employment.

Sometimes a third system of contract is found convenient. It is this The contractor is to purchase all the necessary materials at your expense in consultation with you or your mistry. He is also to arrange for the labour, the weekly payment of which will be done by you He is further to supply all the necessary equipment such as mortar mill, scaffolding material, sieves, tools etc. etc free of hire and finish the work within a specified time. The accounts are carefully kept by your man and the contractor is to be finally paid, for his advice and supervision and hire of equipment, a certain percentage of the total expenditure (usually not exceeding 10 per cent). In this you have simply to keep a check on the accounts and the whole work is simplified. The only drawback of this system may be that as the contractor's commission is a certain percentage of the total expenditure, he might use costlier and stronger material to increase the cost. For safeguarding against this, detailed specifications or at least detailed plans and estimates specifying the correct size and quality of materials may be obtained from an experienced architect before making an agreement.

FORM OF CONTRACT AGREEMENT

One Rupee Stamp

ARTICLES OF AGREEMENT made the———date of———————19——

BETWEEN ——————————————————————————————

of ——————————————————————————————

(hereinafter called "the Employer") of the one part and——————————————

——————————————————————————————

of ——————————————————————————————

——————————————————Builder ——————————

(hereinafter called "the Contractor") of the other part WHEREAS the Employer is desirous of building——————————————————————

——————————————————————————————

at ——————————————————————————————

and has caused Drawing and a Specification describing the work to be done to be prepared by of

AND WHEREAS the said Drawings numbered I to——————inclusive and the Specification and the Bills of Quantities have been signed by or on behalf of the parties hereto AND WHEREAS the Contractor has agreed to execute upon and subject to the Conditions and Specification set forth in the Schedule hereto (hereinafter referred to as "the said Conditions") the works shown upon the said Drawings and described in the said specification and included in the said Bills of Quantities for the sum of Rupees——————————————————————

——————————————————————————————

NOW IT IS HEREBY AGREED AS FOLLOWS —

In consideration of the said sum to be paid at the times and in the manner set forth in the said Conditions, the Contractor will upon and subject to the said Conditions execute and complete the works shown upon the said Drawings and described in the said Specification and included in the said Bills of Quantities

The Employer will pay the Contractor the said sum or such other sums as shall become payable hereunder at the time and in the manner specified in the said Conditions

The term "the Architects" in the said Conditions shall mean the said or, in the event of their ceasing to be the Architects for the purpose of this contract, such other person as shall be nominated for that purpose by the Employer, not being a person to whom the Contractor shall object for reasons considered to be sufficient Provided always that no person subsequently appointed to be Architects under this Contract shall be entitled to disregard or overrule any decision or approval or direction given or expressed by the Architects for the time being

The within plans, agreement, specification and documents abovementioned shall form the basis of this contract and the decision of the said Architects or other Architect for the time being as mentioned in the printed conditions of contract in reference to all matters of dispute as to material, workmanship, accounts, measurements or final certificate and as to the intended interpretation of the clauses of this agreement, specification or any other document attached hereto, shall be final and binding on both parties and may be made a rule of Court

The said Conditions shall be read and construed as forming part of this Agreement and the parties hereto will respectively abide by and submit themselves to the conditions and stipulations and perform the agreements on their parts respectively in such conditions contained

These presents witness that the said Contractor for himself, his heirs, executors, administrators and assigns hereby agrees and contracts to erect such building and all other works necessary to thoroughly complete the same at the rates mentioned in the said Tender and to execute the entire work in accordance with the said drawings, estimate, printed Specification and General Conditions of Contract above referred to and in accordance with the Architects' written or verbal instructions and to their entire satisfaction

The said contract comprises the buildings abovementioned and all the subsidiary works necessary to compelete the same as may be ordered to be done from time to time by the said Architects or other Architect for the time being even though such works may not be shown in the darwings or described in the Estimate or Specification

The Architects reserve to themselves the right of altering the drawings and nature of the work and of adding to or omitting any items of work or of having portions of the same carried out departmentally or otherwise and such alterations or variations shall be carried out without prejudice to this Contract

As witness our hands this——————day of——————19——

Signed by the said

____

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in the presence of

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Signed by the said

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in the presence of

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SCHEDULE OF CONDITIONS OF CONTRACT

For want of space it is not possible to lay down these in detail in legal language They are simply enumerated here —

(1) The work to be carried out according to signed drawings, specification and further detailed drawings which may be provided by the Architects as the work progresses One complete set of drawings,specification and schedule of quantities shall be provided duly signed by the Employer or the Architects appointed by him

(2) The estimated quantities of work are only approximate Bills are to be made on the quantities actually done and measured Should any error appear in the schedule of quantities other than in Contractor's prices and calculations it shall be rectified

(3) The Contractor to set out the works at his cost and to amend any errors arising from inaccurate setting out

(4) The responsibility of conforming to the provisions of any Acts of Government, Bye-laws of Local Authority etc will lie with the Contractor The Contractor to indemnify the Employer against all claims of patent rights and to pay all royalties, licence fees, lighting and water charges etc required in connection with the execution of work

(5) The Employer or his Architects are at liberty to omit one or more items of work in the estimate

(6) The Contractor shall dismiss from the works any person employed whom the Employer or his Architects might regard unsuitable, incompetent or undersirable

(7) The Employer or his Architect or any persons appointed by him shall have access to works at all times for checking, measuring or inspecting any part of the work

(8) The Contractor shall not make any additions alterations to, or omissions from the works shown on the drawings without the express written authority from the Employer or the Architect A verbal authority must be got confirmed in writing

(9) The Employer or his Architects shall have power to order in writing the removal from the works, within reasonable specified time, of any defective materials or faulty construction and substitution of proper materials or workmanship In case of default on the part of the Contractor, they have power to carry out the same at the Contractor's cost

(10) If the Employer or his Architect employes other suppliers or contractors for work not included in the main contract, the main contractor will give them all reasonable facilities for the advancement of the work

(11) The contractor shall not assign this contract or sublet any portion of it without the approval of the Employer or his Architect and when it is sublet with approval the responsibility of using good materials and workmanship will rest with the main contractor

(12) The contractor shall notify in writing to the Employer or his Architects when foundation or slabs, columns or beams etc of R C C are ready for concreting and in the case of all such works as are to be covered and thus difficult of inspection afterwards, to inspect and pass an order for filling them.

(13) If the Employer or his Architect wants to inspect or measure any part of the work, which is covered up, the contractor shall, at his request, open it up at his cost.

(14) The contractor shall be responsible for all injury to persons or animals, or damage to property, which may arise from neglect or carelessness of his own or his sub-contractors or their employees or accident or any other cause whatever connected with the work He shall indemnify the Employer against all claims for them The Employer is at liberty to deduct the amount of any damages, compensation, costs, etc arising from such claims from the dues payable to the contractor

(15) The contractor shall keep the work insured against loss or damage by fire, accident or earthquake until the virtual completion of the contract and the policy covering the property of the Employer and the fees of the Architect, shall be deposited with the Employer

(16) As soon as possession of the premises is given to the contractor he shall start the work immediately, maintain steady progress and shall complete it so as to be ready for occupation within months from the date of formal handing over of the site

(17) If the Employer or his Architect thinks that the work is delayed by (1) exceptionally inclement weather, (2) consequence of dispute with neighbours, (3) authorised extra work, (4) strikes or lock-out affecting building trade, (5) not having received necessary instructions from the Architect for which he had applied in writing and (6) other causes which the Architect may certify to be beyond the control of the contractor, a fair and reasonable extension of period may be given

(18) If the contractor fails to complete the work within the original or extended time if any, he shall pay to the Employer the sum of Rs per day as penalty

(19) If the contractor fails or neglects to proceed, with due diligence, with the work, or shall make a default, more than once, in respect of faulty materials or defective workmanship, the Employer or his Architect shall have power to give notice in writing to the contractor regarding work to be carried in reasonable manner and with despatch After such a notice is given the contractor shall not remove from the site of works any plant or materials belonging to him and the Employer shall have a lien on all these. If the contractor fails within days after the notice to proceed with the work as prescribed, the Employer may take possession of the work and site and everything lying upon it and may engage any other person to complete the work, to the exclusion of the contractor or his men Upon the completion of the work if it is found that the amount spent is less than that due to the contractor for completion of the work, the difference will be paid to the contractor If, however, it is more, the contractor will have to pay the difference

(20) If the contractor finds that certain items of work which are necessary are not provided for in the schedule of rates, he shall apply in writing to the Employer or his Architect for settlement of their rates before he undertakes execution of such "extras" If agreement is not reached about the rates of such "extras" the contractor will keep accurate accounts of them including cost of materials and labour, to the satisfaction of the Employer or his Architects and the Employer will give him %for his supervision over and above the cost

(21) Where "Prime cost" (P C) prices or provisional sums are provided for any items in the estimate, they are exclusive of any trade discount, discount for cash or the profit which the contractor may require for carriage and fixing

(22) All goods required for the above items may be selected and ordered by the Employer or the Architect and they reserve to themselves the right of making payment for them, which shall be deducted from the amounts due to the contractor

(23) The Employer reserves to himself the right to use the premises and execution of any work thereon by other persons not included in the contract

(24) The contractor will be entitled, under certificate from architects within days of the date of certificate, to payment by the Employer %of the value of the work certified. The remaining will be kept under deposit as retention money, which will be paid when finally certified by the Architect for payment at the expiration of months after the final completion of the work and after all defects are set right If the amount certified is not paid within the specified time after issue of certificate, it will carry interest at the rate of per cent per annum

(25) The contractor shall amend or make good any defects due to shrinkage, settlement or other causes such as leaks in roof, blisters on wall surface, choking or unsatisfactory working of drains and sanitary fittings etc etc due to improper materials or bad workmanship The retention money will be paid only after all these defects are set right within such reasonable time as specified in writing either by the Employer or the Architects In case of default the Employer may employ and pay other persons to set right the defects and the expenses consequent thereon shall be deducted from any moneys due to the contractor

(26) If the contractor receives an order in Bankruptcy against him and makes an assignment of the sums due to him to his creditors or suffers any payment under this contract to be attached or neglects to abide by any of the conditions of this contract particularly in respect of using proper materials or workmanship, or maintaining steady progress of work so as to complete it within the specified time, then the Employer may take possession of the works, tools, plant and materials laying upon the premises and adjoining lands and roads and sell and use them in his own property and get the work completed by other persons in accordance with clause 19

On the other hand if payment of the amount certified by the Architects together with interest remain in arrears for days after notice in writing shall have been given by the contractor to the Employer or if the Employer shall have a receiving order in Bankruptcy made against him then the contractor shall be at liberty to terminate the contract by notice to the Employeror or Architects and shall be entitled to recover from the Employer all his expenditure and any loss he may sustain.

(27) In case a dispute arises between the Employer or the Architect and the contractor except as to the matter left to the sole discretion of the architect under clauses, each party will appoint its own arbitrator, who both will appoint an umpire. If the two arbitrators agree, their decision will be final and binding on both the parties If they disagree, the umpire's decision will be the final one

LOCATION OF THE HOME IN THE BUILDING PLOT

This question has been discussed in detail in the author's "Modern Ideal Homes for India" in connection with landscape gardening However. a few salient points if mentioned here will not be out of place.

(1) For provision of adequate light and sun the minimum space between two adjacent houses should be equal to the height of the taller house out of the two.

(2) More open space should be left on the side of the direction of the prevailing wind and it should be, if possible, minimum of $1\frac{1}{2}$ times the height of the building on that side.

(3) The minimum width of carriage walk or car-drive should be 10 feet. If this be alongside a boundary, a strip of 15 feet width should be left between the main house and the boundary including 3 feet for the boundary hedge, one foot for shrubs in the front corner between the house and drive-way.

(4) Ths exact minimum distance specified by the local authority between the street edge and building line should not be adopted. As light variation to break the monotony is desirable.

(5) It is a mistake to place a home in the centre of the plot, especially if the latter be small. If the building be placed on one side of the axis, the space left on the otherside, can be more usefully employed either for beauty or utility.

(6) A yard for drying clothes is a necessity for a family. The proper position for it is close to the house on the back side and if it is apparent from the front it should be suitably screened by either a shurubbery or a hedge.

(7) Proper placements of servants' quarters, latrines if they be outside the building. a shed for burnishing, cooking utensils and washing clothes with a water cistern nearby,

and a motor garage and a vegetable garden if space permits, should be thought out

It would be very helpful if a plan of the proposed building is drawn to the same scale as that of the site plan and if cut along its outline by means of a pair of scissors. This cutting should then be moved on the site plan and the location which gives the best position in the light of the above remarks and the municipal requirements should be finally adopted.

THE BEST SEASON FOR STARTING BUILDING OPERATIONS.

This depends upon a number of factors Obviously it is risky to start the work in the rainy season if the walls be of sundried clay bricks or even of stone or burnt brick in mud. The progress of work even with walls in lime or cement mortar is hindered by rain. However, the general moist weather in that season is helpful for the setting or hardening action of lime or cement.

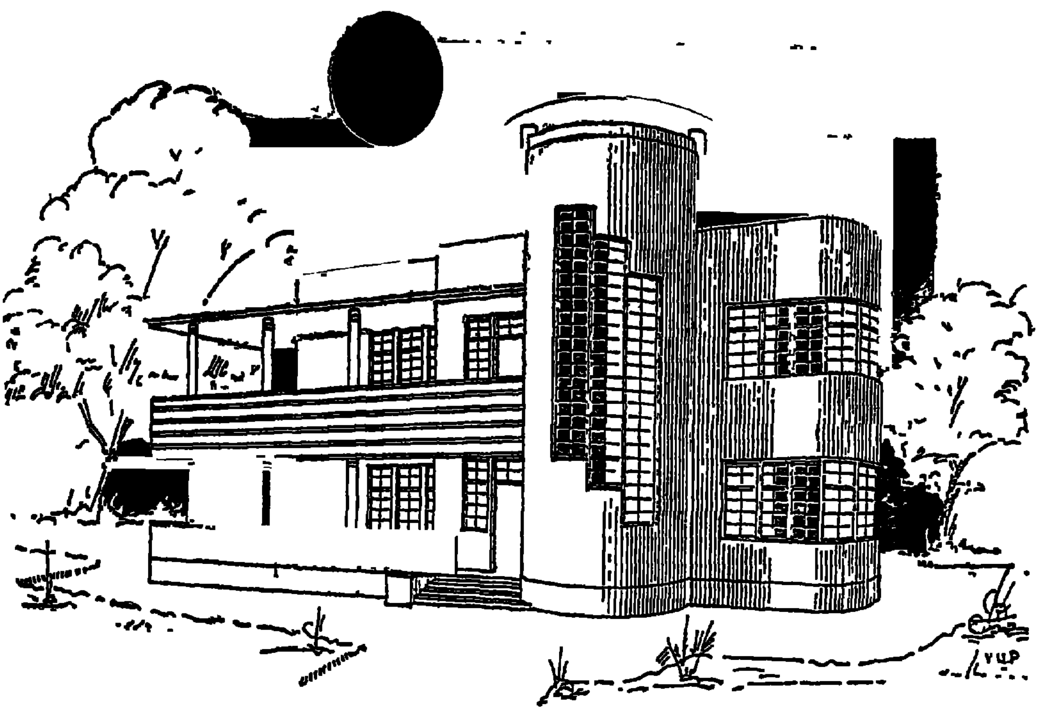


Fig 15

If the house be of medium size suitable for an average family, it is possible to finish the work from the foundations to roof in 3 to 4 months. Still, it is safer to allow at least five months It should be remembered that if the work lingers on, the cost unnecessarily increases. Too much haste, on the other hand, is also detrimental to the strength of the structure It is generally admitted that no wall, in lime mortar, should be raised to more than 2½ feet in height in a single day. Otherwise the mortar in the lower joints is squeezed out by the upper weight of the wall. This rule is not applicable when cement mortar, which sets in a few hours, is used in stead.

In winter the days are short and it is not possible to start work earlier than at 8 a.m. Besides, the progress of work within the first hour or so is not satisfactory on account of bitter cold. Again, work has to be closed by 5 p.m. in the evening, as the workmen have to wend their long way home before dark. Thus with a respite of one hour for midday meals, the working period amounts to 8 hours, whereas, in the hot weather season the actual working period form 7 a.m. to 6 p.m., with the same middayrespite, is 10 hours. This means 25 cent. more work within the same cost.

The work should, therefore, be started at such a time that it should be possible to put the roof covering about a month before the usual first showers arrive. Once the roof covering is on, the internal finishing, such as plastering, paving, distempering etc., can be continued even during the rainy season.

In a tropical country like India, the plaster of walls dries up in less than two weeks even in the rainy season except perhaps in regions of heavy rainfall.

PRELIMINARIES.

When the plan is finally decided upon three copies of its blue print are required to be sent to the local authority. A printed form obtainable free of charge is to be filled in and submitted with the plans. If no sanction is received within a month, the owner is entitled to start the building work, according to the Municipal Act.

While the sanction is awaited it is advisable to utilize the time is getting the boundaries checked. It is also advisable to explain to the adjoining neighbours on both sides the general layout of the house you are going to build to dispel their fears, either real or imaginary, about encroachment upon their land or privacy, etc., and take their consent. This little timely precaution will save the owner endless trouble and litigation later on and help maintain good relations with the neighbours.

If it is intended to get the work done on daily wages there are several things that must be attended to before starting the work. These are:

(*a*) Purchasing tools such as iron baskets, pick axes, shovels, rammers, crowbars, a 50 feet tape, a foot rule and a few sieves for sand.

(*b*) Purchasing materials such as stone metal or kunker for concrete, slaked lime, sand, rubble, burnt bricks and timber for door and window frames. These and other materials required at a later stage are separately discussed in an appendix.

(*c*) Arrangement for a mortar mill for grinding lime mortar with a "tell-tale" if lime mortar is to be used.

(*d*) Water cistern.—This should be centrally situated with respect to the mortar mill, where the lime is ground and the building, where it is used. The size of the cistern will depend upon the source and

quantity of supply of water. If plenty of tap water be available for 24 hours of the day the cistern need not be large The cheapest way of making a cistern is to lay paving slabs on, say, 4 inches of lime concrete with joints about $\frac{3}{4}$ inch wide and to build up on this platform $4\frac{1}{2}$ thick walls of brick in lime, which should then be lined with paving slabs laid vertically also with $\frac{3}{4}$ inch wide joints. The mortar from all the joints should be raked out and cement mortar, made of one part of cement to four parts of sand, filled in them. When the work is finished all the slabs can be removed and used elsewhere.

(*e*) A mixing platform.—For this a flat piece of ground say 15′ x 20′ should be selected, close to the building, levelled, watered and rammed or rolled. On this should be spread $\frac{1}{2}$ inch thick layer of sand and paving slabs $1\frac{1}{2}$ inch thick and of as large a size as available, should be laid dry with joints about $\frac{3}{4}$ inch wide. These joints should be filled with sand. When this platform is used for mixing lime concrete some of the lime slurry will fill the interstices between the grains of sand in the joints and the whole surface will be made reasonably watertight. At the close of the building operations the paving slabs can be removed and used in servants' quarters or motor shed.

(*f*) A shed for a chowkidar or gate-keeper, also one for the carpenters and another for a small store for storing cement and such other materials as cannot be exposed to atmosphere. On one side of it, a small office should be made for the supervisor to accommodate a table for spreading out plans, and for one or two chairs. All these sheds may be made

of frame work of round teak rafters to which bamboo matting may be nailed both for sides and also roof If necessary, a few corrugated iron sheets should be used for roofing and also sides of the cement store, if early rains are expected. These sheets will be ultimately useful for the washing shed. A chowkidar or a watchman will be required to live on the premises day and night during the period of the construction.

The materials required for the construction should not be purchased and brought on site all at once, but a definite arrangement should be made for their continuous supply as they would be required. A stock sufficient to last for two weeks should always be maintained on the site.

Care should be taken to heap all the materials separately in neat stacks and a strict warning should be given to all concerned to maintain the stacks neatly *i.e.* never to allow the materials to lie scattered about. This, not only presents a neat appearance, saves time and space and avoids confusion, but, is also very economical in the long run. Some of the materials *e,g*, bricks, paving slabs, etc., are liable to break and go to waste if the above precaution is not taken.

It should be remembered that in place, where lime has to be brought from long distances, say, exceeding 5/6 miles, where, the lime also is not of uniform good quality, it is uneconomical to use it. Instead of that, cement mortar, even so lean as one of cement to ten of sand is equally strong and cheaper, and besides possesses certain other advantaegs which are discussed later on a special chapter.

FOUNDATIONS

Foundation is the most important matter in the construction of any structure. No matter how substantial the superstructure, how beautiful and ornate the facade, how leak-proof the roof, and how costly the equipment and furnishing, if the foundations are weak, these are all wasted.

It is, therefore, prudent to make the foundations even a little stronger than necessary in the beginning, because if this matter is overlooked at this time, it can never be properly set right afterwards. Even if only a ground floor structure is desired to be built now, it is possible that the owner may contemplate raising another floor on its top some time in future, but if the foundations constructed are just sufficiently strong to bear the weight of the ground floor structure only, the idea of raising a floor will have to be altogether abandoned. Making the foundations strong enough to bear the weight of two storeys may cost only a hundred rupees or so more.

The purpose of foundations is two fold : (1) To connect or tie the structure down to the ground so that it may not slide down or move away from the ground and (2) To distribute the weight of the building on a larger area. The former is accomplished by excavating foundation trenches to a sufficient depth below the ground and build from there so as to give some foot-hold to the building in the ground, and the latter, by widening the bottom of walls by means of footings as shown in figure No. 16 in which the upper wall is only $13\frac{1}{2}''$ thick and yet the base is widened to $39''$ or roughly 3 times as much by providing offsets on both sides of it. The result is that if the weight coming on the wall is say 9 tons per sq. foot it will be only 1/3rd of it or 3 tons on the soil at the base. An analogy will make this point clear. If you walk on a soft or marshy ground your feet will sink into it to a certain extent. If, however, you walk on a wooden

plank placed on the same ground the plank will scarcely sink down. Because your weight which was formerly concen-

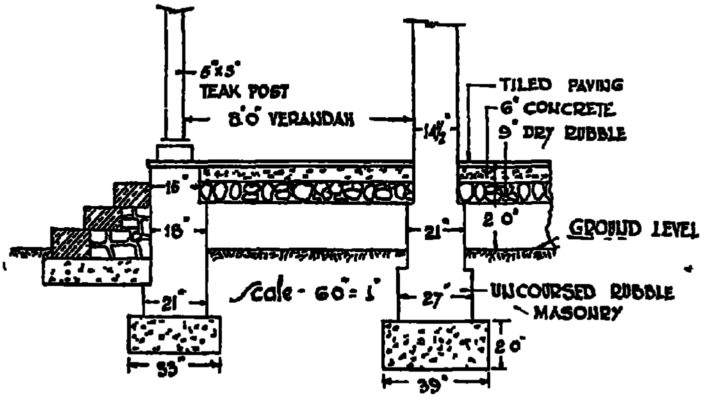


Fig. No 16

Footings of foundations,
A cross section accross the verandah

trated over an area equivalent to that of your feet is now spread over the area of the plank.

Different soils have different bearing power ; for instance, black cotton soil will bear only ½ ton per square foot, while sandy soil will take about 2 to 3 tons and compact clay even upto 4 tons per square foot. If the load of the building coming on the foundation exceeds this bearing power, naturally that part of the building where the load is in excess will sink down, *relatively* to the other parts and a crack will be formed in the wall. If the whole building were to sink or settle down uniformly cracks would not be formed. But this is well nigh impossible. Because one part of the building may be taller and thus heavier than the other and the heavier part will exert more pressure. Again, all the walls are not of the same thickness. Hence, by widening the footings of walls we seek to reduce the intensity of pressure, so as to make it less than the bearing power of that particular soil.

Rock and hard murum at surface, though they save cost of foundations and do not absorb moisture, are bad. For,

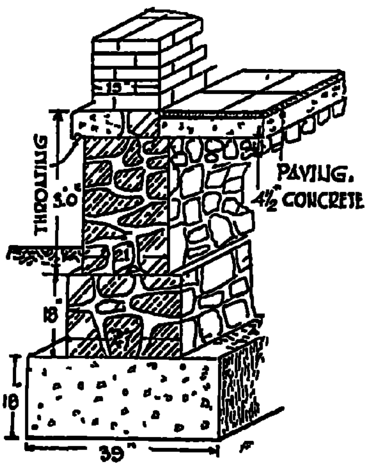


Fig No 17.

The foundation trench is 3 ft below ground & is filled with 18" of concrete & 18" of rubble masonry Plinth is 3 ft. high including a layer of 6" of cement concrete coping

excavation for drains is very costly, trees and plants in garden do not flourish well and further, they absorb heat of the sun by day and radiate it very slowly, long after sunset and make the house hot.

Soil at surface 2 or 3 feet deep overlying murum (disintegrated rock) are the best foundations. Next best are gravel or sand mixed with a little soil These easily drain off rain water, but unless the site is lying high, there is the possibility of rise of subsoil water table in the rainy season. Besides, sandy soils tend to make the house hot.

Clay, if it be firm and compact, say, about 3 or 4 feet deep overlying sand, murum or kunker,forms very satisfactory foundations for ordinary light buildings of the residential type.

If the clay is suspected to lie to an indefinite depth, the foundation trenches should not be excavated to more than 4 or 5 feet depth. It is not economical to go deeper than 5 feet for foundations. If the clay be compact and firm, the trenches should be widened slightly more and the foundations may be allowed to rest on it at a depth of from 3 to 5 feet.

There is a special purpose in going to a depth of at least three feet even if the soil above be sufficiently firm and compact. For, it is generally believed that the effect of the atmospheric influences reaches upto three feet depth in soil below ground surface.

For ordinary houses of two storeys, firm clay, if it is not of the nature of black cotton soil, affords very satisfactory foundations. The latter absorbs moisture, swells, loses cohesion, and has a tendency to exert a considerable side push on the walls underground and when it dries up again, shrinks enormously, forms deep cracks and exerts a pull, and causes cracks in the structure. Thus black cotton soil is dangerous for foundations and the only satisfactory remedy so far known, is to provide reinforced cement concrete foundations. There are two ways of doing it. (1) To cast reinforced cement concrete beams at the bottom of foundations and (2) To make the footings of walls in the ordinary way and when the plinth level is reached, to lay 6 inches thick reinforced cement concrete coping, instead of one of bricks or stone in the usual manner. The coping must be laid on top of internal walls also. Here it may not project beyond the wall face. In addition to this another layer of reinforced cement concrete about 4″ to 6″ thick is to be laid at the top of doors and windows, in which case, lintels may be dispensed with.

If firm earth or sand or murum is not met with even upto 5 feet below the ground surface, bore holes or small pits may be dug in one or two corners to see what is lying below and if it is not still found even up to 7 feet one of the following remedies may be adopted.

(1) Excavate trenches, say, upto 5 feet depth in the soil, put about 2 feet deep layer of sand, ram it well *without* sprinkling water and rest the concrete and other footings on its top as usual. Sand and gravel are incompressible and provide excellent material for foundations if there is no possibility of their spreading out or moving towards sides under the weight of the building. Hence, this method is not suitable in black cotton soil, because, when it cracks, the

sand in the vicinity of the cracks is likely to spread out and fill the cracks leaving a hollow at top below the concrete of foundations. For the same reason this method should not be adopted on sites close to steep sloping banks of rivers or streams where the foundations are likely to be exposed by the scouring action of water, or even by rats or bandicoots, making holes, through which, sand below the foundations might leak out. In any case, the top of sand should be at least three feet below the ground surface.

(2) If rock or hard murum is met with at say 8 to 10 feet below the surface, pits 3 or 4 feet square should be excavated in all the corners and at intervals of 8 to 10 feet between them along foundation lines. These should be filled with lime concrete in layers of nine inches upto, 4 feet below ground surface and rammed well so as to form concrete pillars. Then trenches of the same width as these pillars should be excavated between the pillars in such a way that each forms a sort of arch excavated in soil. Concrete should then be filled in layers in and between the concrete pillars as shown in figure 18 and rammed well. On the top of this concrete the usual foundation should be laid. The whole thing forms a sort of concrete pillars and arches, hidden below the ground surface. The whole weight of the building is thrown ultimately on the rock at bottom through the arches and the pillars supporting them. The construction of arches in this case is very easy and cheap as concrete has simply to be poured in to trenches and rammed. No bottom or side supports are required as in the case of arches built above ground.

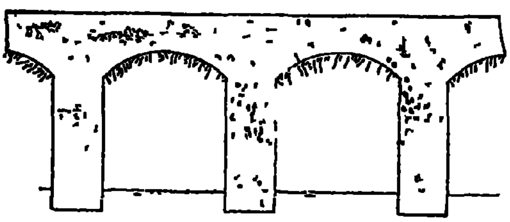


Fig No 18
Concrete pillars and arches

(3) The next method is just the reverse of the above. In this, trenches are excavated in the form of inverted arches, *i.e.*, instead of curved humps in the centre as in (2) above, hollows are to be made by excavating earth, and inverted arches and pillars are to be constructed either in stone rubble or brick in lime. The pillars and arches are carried to about 2 feet below the ground level and on their top reinforced cement concrete beams are constructed and regular walls raised on the top of the latter.

(4) On the same principle as the two methods discussed above, but with elimination of arches, piles are driven under ground instead of pillars. These piles may consist of wood, resistant to decay and white ants, or of steel or reinforced cement concrete and are driven by continuous blows of a heavy steel hammer worked from a tripod, either by manual or engine power and when they reach sufficient depth, to cast reinforced cement concrete beams on their top and the walls are constructed on the top of these beams. This method, however, as it requires the pile driving machine, is not suitable for individual house builders, unless they combine and buy or hire it on a co-operative basis when there are number of buildings are to be erected.

(5) Reinforced cement concrete beams either at the bottom or at plinth and door top level as described above for foundations in black cotton soil.

When the surface of the ground is sloping considerably, instead of excavating a trench with bottom sloping, parallel to the ground surface or a level bottom with considerable depth at the upper end, stepped foundations are more economical.

SETTING OUT FOUNDATIONS.

If the work is given by contract, the contractor is responsible for setting out the foundations correctly. If it is done on daily wages the mistry in charge usually does it. Still it is advisable that the home builder should be acquainted with the principles involved in it.

It would avoid confusion and facilitate the work considerably if a foundation plan is got drawn with all the measurements shown on it. It is a very easy matter and the mistry should be able to do it.

The usual method is to assume one line (usually the centre line of the longest outer wall) as the base line and to set out the centre lines of the outer side walls very correctly at right angles and the fourth line parallel to it at proper distances apart. The diagonal distances should be equal to each other if the lines of correct length are set accurately, at right angles to each other. The right angles are usually made by means of the mason's square, but as it is a small and rough instrument, correct results are not usually obtained at the first attempt. Instead of this the right angles can be set out mathematically to any degree of accuracy in the following manner:—

Drive a wire nail on the top of a peg to mark the extreme end of the centre line on the base line and another on a similar peg at exactly six feet inside it on the same line. Insert a loop of a thin wire round the former nail and draw an arc with a radius of eight feet; similarly, insert a loop of another wire round the latter nail and with a radius of ten feet draw another arc of a circle; the point of the intersection gives you a correct point on the line at right angles to the base line. The object is to form a triangle of three sides 6, 8 and 10, the two sides, 6 and 8 feet long of which, must subtend

a right angle. When the centre lines of outer walls are correctly laid out, it is comparatively very easy to set out other lines parallel to them simply by measuring distances.

The 8 pegs used for the centre lines of outer walls should be rather stout ones and should be driven at least five feet away from the outer trenches and should be preserved till the foundations are filled a little above teh ground level. They are useful for checking the measurements any time in the event of a doubt arising. For correct setting out a few precautions are necessary. They are: (*a*) The twines, particularly if they are of cotton, should be stretched very tight; (*b*) If the ground is sloping considerably all the lines should as far as possible be at one level viz., that of the peg on the higher side; if distances are measured on the sloping surface of ground an error will be introduced. (*c*) The setting out should not be done when there is high wind. For, the tape is bound to swerve from straight lines by the force of wind; (*d*) Before the cotton lines are removed, powder of slaked lime or white earth or ashes, should be sprinkled along them, so that when the lines are removed, this makes the entire layout visible on the ground.

It should be remembered that the widths set out on the ground are required at the bottom of the trenches and, also that if the depth of trenches is considerable, their sides must be kept sloping. Thus the top width of the trenches will be more than the width shown by the lines. If the sides are excavated to a vertical face, slips will occur and the trenches will be widened and require greater amount of concrete to be put in. For this reason it is advisable to expedite excavation of trenches and fill them up with concrete and masonry without losing time. If the depth of trenches exceeds six feet, the sides must be supported against slipping by horizontal, planks on both sides by an arrangement called 'shoring'.

Precautions :—

(1) When the trenches are excavated fully, the strings should be stretched again on top of the ground and the bottom widths may be tested by dropping plumb bob just touching the lines and if the widths are less, or the sides obstruct the plumb line, they should be cut. This is very important and if neglected at this stage it will be found, after the concrete is filled in, that part of the upper wall to be built, if constructed according to the design, will go out side the concrete below.

(2) The tendency of the workmen or contractors, unless a definite mention is made to the contrary in the specifications, is to make a heap of the earth or other material excavated from the trenches just by their sides in the space between the trenches just to save their labour. Sometimes they try to convince the owner that this space is ultimately to be filled up to plinth level, and so they are doing the right thing. But this is a mistake. If a heap is made here, firstly, the sides of the trenches are likely to slip under its weight. Secondly, under the vibrations caused by the process of ramming concrete, or, by the movements of people going from one side of trench to the other, the loose earth heaped up as above falls on the top of the concrete and mixes with the mortar and is very difficult to remove. Besides, it causes great difficulty in movement from one side of the trenches to the other.

(3) If it is cement concrete it must be rammed vigorously immediately during about 15 minutes after laying. If ramming is continued afterwards not only it is of no use, but on the contrary it would do harm. Because, cement begins to set within half an hour after mixing and if its setting action is disturbed its strength might be impaired.

If, however, it is lime concrete it may be rammed for two or three days. But the ramming done for the first few hours immediately after it is laid, is of the greatest importance.

The test of proper mixing and ramming is that in the process of ramming all the aggregate should sink down and the cream of lime should come up to the top.

LAYING CONCRETE IN FOUNDATIONS.

The object of filling concrete in foundations is threefold: (1) If the bottom of the trenches such as in rock is uneven, *concrete fills the hollows and makes it even*; *(2) Concrete forms* a sort of thick beam and if the soil is likely to yield slightly under pressure, this beam prevents it and (3) That the weight of the building is distributed over a larger area.

The proportion in which the different ingredients of concrete are mixed together and the manner of mixing, etc., are discussed in the appendix.

Before laying concrete, copious water should be sprinkled on the bottom; otherwise, if the surface be of absorbent material it will suck water from the concrete and prevent it from setting.

Concrete should be laid in layers not exceeding nine inches in thickness, which by ramming would be reduced to 8 inches or less. Coolies are prone to stand on the edge of the trench and drop concrete to the bottom from that height. This is very bad. For, the pieces of stone metal, which is called 'aggregate' being heavier is easily separated from the lime and drops down first, and the lime afterwards; thus the two ingredients are separated. The proper way is, that a man should stand in the trench and should receive every basket of concrete in his hand, lower it down to the bottom, drop it with a bang, so as to drop also the mortar sticking inside the basket, and make suitable heaps close to each other to form a layer of the desired uniform thickness. Some people are in the habit of spreading a thin layer of lime mortar on the top of concrete in order to cover bad work. *This should never* be allowed.

During the process of concreting and a few days even afterwards, copious water should be sprinkled 3 to 4 times a day on the top, to help the setting action of lime.

Special care should be taken to see that the sides and corners of concrete are well rammed by special flat rectangular rammers or wooden hasps.

MASONRY IN FOUNDATION.

If there is rock at the bottom of trenches concrete may be laid just sufficient to fill up the hollows and make the surface plane. If foundations are in rock, sometimes concrete is altogether omitted.

If the surface of the rock is sloping considerably, level steps should be cut into it with a chisel and masonry laid on them. Otherwise, the masonry might slide down towards the lower end of the slope.

If the foundation trenches are more than two feet wide, masonry is laid on the top of the concrete leaving equal offsets on both sides. As the masonry will be ultimately hidden underground, large stones of rough and irregular surface are used without dressing even with a hammer.

To ensure the best quality of masonry work, and to avoid the common mistakes made by careless masons, the layman is advised to attend to the following practical points :—

(1) The larger and heavier the stone the better it is. The only thing is that the stone should give a ringing sound when struck with a hammer; if it has a crack or similar flaw it will sound hollow.

(2) Every stone should be wetted with water on all faces before being laid.

(3) It should then be laid on its flat face on a bedding of fairly stiff mortar.

(4) As soon as a stone is laid in mortar it should be struck with a hammer with medium force.

(5) The longer side or the tail of the stone should go into the width of the wall i.e., at right angles to the face of the wall.

Header stones should be laid at 6 ft. intervals in each course. They should be two faced if the wall be 2 ft. or less in width and if it is wider two single faced headers, one on each side should be so laid as their tails will overlap at least 6".

(6) When three or four stones are thus laid side by side on one face on mortar bedding, the other face of the wall should be similarly completed or better still, both the faces should be done at the same time.

(7) After this, mortar should be laid round the stones inside the wall and smaller stones or large chips, already moistened with water should be laid each with a stroke of hammer on it.

The big stones together with smaller ones should form one compact body.

(8) Greater strength is secured by using as large stones as possible both on the faces and in the hearting of the wall. Too much mortar weakens the masonry. The real skill lies in selecting a stone of such a size and shape as will just fill the hollow and get interlocked.

(9) In no event should the masonry be allowed to dry up for at least fifteen days after it is laid. Water should be sprinkled at least 3 to 4 times during the course of the day.

(10) A very rough and uneven top of each course of masonry is preferable. Hence, no attempt should be made to make it plane by laying small chips of stone in the mortar.

The practice of laying long lines of dry stones on both the faces and pouring baskets of thin grout of mortar on top which bad masons or contractors are prone to do under slack

supervision is to be severely deprecated. It should be noted that the mason is interested in piling up "more cubic feet" to show more work in given time.

PLINTH.

As the foundation masonry is hidden underground and supported on all sides by the soil, it is not necessary, both in the interest of appearance as well as stability to use corner stones in it, as they are costly. The foundation masonry is usually carried to about one foot to six inches below the ground surface and on its top the plinth masonry is commenced leaving equal offsets on both sides.

For the plinth the main corner stones of the outer walls are first laid, by setting out correctly the face lines of the plinth masonry with the help of the reference pegs specially preserved (vide page 97) The procedure is similar to that of setting out foundation lines, with the addition that the tops of all the corner stones must be at the same level. If the building is an important structure this is done very accurately by means of the surveyor's levelling instrument; otherwise by means of an ordinary spirit level.

As the entire load of the building falls on the corner stones of the plinth masonry and as unlike the underground masonry the latter is not supported on the sides by earth, it is necessary that the corner stones should be pretty large and heavy. 12″×18″×15″ if not larger, is a suitable size. If stone is scarce and corner stones, therefore, very costly, corner blocks of cement concrete, in the proportion of one part of cement to 2½ of sand, and 5 of stone aggregate of ¾″ size should be cast into moulds. As a matter of fact all the corners even above the plinth may be prepared of cement concrete even though the masonry be of burnt brick. They are cheap, strong and can be treated as an architectural feature.

The object of plinth is to raise the level of the house floor above the ground so as to keep it dry even in the rainy season.

Incidentally, it heightens the beauty and dignity of the building. However, for domestic buildings, too high a plinth gives a feeling like a bird perching temporarily on a height Too low a plinth is bad both from a sanitary point of view, and because it gives a stunted and insignificant appearance to the house. $1\frac{1}{2}$ to 3 feet is a suitable height for buildings of cottage type, unless other special circumstances necessitate an increase.

A layer either of finely dressed stone, cement concrete or two courses of burnt brick plastered over, projecting about $\frac{1}{2}$ inch outside, called 'coping', is usually constructed in the outside walls with its top flush with the floor level. Its object is twofold: (*a*) As it projects a little outside, the rain water striking against the face of the exposed walls should drop down away from the face of the plinth masonry and (*b*) The horizontal band of coping breaks monotony of the masonry courses and acts as an architectural feature. But to achieve the first object, the projection must be longer and must have throating as shown in figure No. 17 and with respect to the second object, it may be said that the extra cost of Rs. 150/- to 300/- if cement concrete or dressed stone coping is laid, is scarcely justifiable in the case of small and cheap homes. That amount can be better spent for providing additional conveniences. Hence, in the case of homes, where economy is an important factor, the coping at plinth level may be safely omitted. In most of the Public Works Department buildings of ordinary type it is omitted.

As far as possible the foundation and plinth masonry should be of stone. But where stone is very costly, overburnt bricks may be used for foundation masonry and even for plinth masonry if the latter is to be plastered over. Over-burnt bricks are very hard and do not absorb moisture and are also cheap.

Points to be noted to guard against bad workmanship in masonry have been already discussed on pages 102 & 103

CELLAR

A cellar, in order to be useful as a cool sitting room particularly in summer, must be well lighted, well ventilated, and quite free from damp But this ideal is very difficult to attain in tropical countries like India, particularly in respect of dampness. unless at a prohibitive cost. Further, of late years great researches have been made and new materials and processes have been invented for insulating walls against heat and it is comparatively easy to specially design one or two rooms on the upper floor which will remain even cooler than a cellar and absolutely free from the disadvantages of the latter. With the recent progress in air-conditioning the air even in the entire house can be made either sufficiently cool in summer or warm in winter, besides, it can be passed into a house through filters so as to exclude particles of dust and other things injurious to health, at a small cost On account of all this the cellar which was until a few years ago regarded as an asset has lost all its importance However, in the days of modern warfare, cellars have again become a necessity as air-raid shelters. This new phase of its utility requires certain alterations in its design. This matter has been fully discussed in a special chapter on constructoin of a house in relation to air-raids.

DAMP AND ITS PREVENTION.

Damp is very bad from every point of view. Apart from the annoyance it causes by unpleasant smell, foul air and mildew which makes it impossible to store supplies or household goods, it is positively dangerous to health and also to the building structure. Damp in the presence of warmth and darkness breeds germs of tuberculosis. Malaria, Neuralgia, acute and chronic rhumatism can be directly traced to it.

It is no less dangerous to the building structure. When it rises into brick work, certain salts, dissolved in it also rise with it, showing themselves in the form of white deposits on

the wall surface. These salts cause the exposed surface of brick work to disintegrate and fall to powder. The action of damp on timber is no less destructive. The very common form of decay in timber known as "dry rot" is due to damp The infection takes place at any stage in the life of timber and spreads with amazing rapidity. It is caused by the growth of a certain fungus and is carried from one place to another by spores. It is encouraged by dampness, warmth and lack of ventilation.

The main sources of damp are (*a*) Damp rising from the soil either through the bottom or through the adjacent ground surface touching the walls.

(*b*) Damp descending into walls from leaking roof whether sloping or terraced.

(*c*) Moisture penetrating the walls by rain during continued wet weather, especially when the home occupies an exposed situation.

Only the first source of damp viz., that rising from soil will be discussed here. Remedies for the other two sources will be discussed later on, in due course, at their respective places. The insertion of a damp-proof course is obligatory under building bye-laws in the western countries. In the tropical atmosphere it is required only under special circumstances.

The damp-proof course consists of a layer of impervious material placed between the ground level and the plinth level.

The following are the remedies suggested for prevention of dampness.

(1) In the first place select a site to make sure that the first point at which water is struck in a pit is at least 10 feet below the surface of ground even in wet season.

(2) Make the ground surface surrounding the house to slope away from the house, so that rain water drains away before it gets time to collect.

(3) If the building is on a hill side make sure that the land above the house is adequately drained *around* the house, rather than *through* it.

(4) Insert a layer of one of the following materials at the plinth level :—

(*a*) Paving slabs at least $1\frac{1}{2}''$ thick of the full width of the walls laid in cement mortar all round.

(*b*) About $\frac{3}{4}''$ to $1''$ thick course of hot asphalt laid all round just below the coping at plinth level on top of walls, both exposed as well as inner.

(*c*) About one inch layer of cement concrete consisting of 1 of cement, 2 of sand and 4 parts of gravel should be laid and kept moist for a day. The next morning hot coal tar or better still cold bitumen should be poured over it to form a uniform layer of $\frac{1}{4}''$ thick. Sand should be freely sprinkled over it, a day allowed to pass, the extra loose sand should be removed and then wall work above it commenced. This is an effective remedy not only against damp but also against white ants.

(*d*) Other materials in common use in western countries are : bitumen felt, lead, vitrified stoneware, two courses of slate or blue brick, etc. Some of them are not available here and the others are costly.

(5) If the foundation soil is very retentive of water like black cotton clay and particularly if a cellar is to be made, certain drastic measures are required to keep the cellar free from damp. Some of them are preventive and others curative.

Among the preventive ones may be reckoned those in which both horizontal and vertical damp proof membrane

is interposed between the building and the surrounding ground like that shown in fig 19 in which below the bottom of the cellar a layer of cement concrete about 3″ thick is laid on top of about $4\frac{1}{2}''$ layer of gravel, then the surface of concrete is given two coats of bitumen after which a thin layer of $\frac{1}{2}''$ to $\frac{3}{4}''$ of bituminous felt sheet is laid and on top of this 3″ of cement concrete is laid. The treatment outside the vertical walls is similar except that instead sandwiching a membrane of bituminous felt between two layers of concrete, it is done between concrete wall on the inside and gravel filling on the outside.

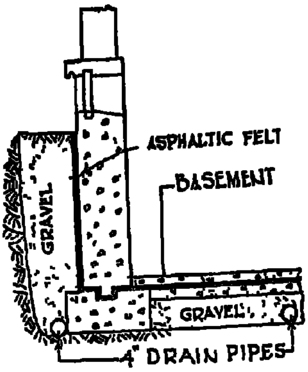


Fig. 19

Constructing a water-tight basement by providing a waterproof layer at bottom and sides and a drain pipe all round the cellar in gravel.

Some times a $4\frac{1}{2}''$ wall of brick is built first on the outside and the main wall is built against it on the inside, leaving between them a hollow space of $\frac{1}{2}''$ to 1″ which is filled with hot asphalt as the main wall slowly rises.

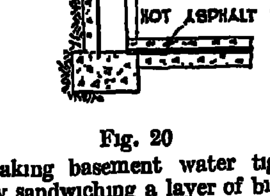


Fig. 20

Making basement water tight by sandwiching a layer of bitumen between outer concrete and inner brick well

At any rate the damp-proof course must always be applied on the *outside* and not inside.

As an instance of curative measure may be mentioned, laying 4 inch drain pipes around the outside of footings in gravel and leading them finally with a suitable slope to a cess pit or dry well from which the water can be pumped out by means of a small hand pump every day. Since water in the subsoil will move in the line of least resistance, it will naturally move towards the pit or the well than through the walls of cellar.

METHODS OF CONSTRUCTION

Framed Structure *versus* Load Bearing Walls.

From very old times until a few years back most of the buildings of residential type were built by the system of "Frame Construction." In this on the top of the plinth masonry a wooden frame or skeleton consisting of vertical posts 5 to 8 feet apart postplates on top of these. and beams of floors carried to any number of storeys. and trusses and rafters of roof above. was first built to support the entire load and then walls usually of stone or brick in mud were built between and round the posts. to function merely as curtains and not bear any weight beyond that of their own.

The advantages of this system are:

(1) Theoretically, the structure should be light as the walls which do not carry any load need not be thick, thus causing a saving also in the foundations But for practical reasons viz., for affording protection from heat of the sun, rain and wind and also from thieves, at least outer walls must be thick enough.

(2) Work can be expeditiously done, as the entire frame work of even several storeys height including the roof need not wait till the walls are raised to their full height

(3) The system admits subsequent additions and alterations in the building to be done very easily. Because as the entire load is supported by the frame, walls could be easily pierced through, or altogether removed. to provide either a new door or a new window or even to extend the house.

(4) If the foundation settles down unevenly there is very little risk to the structure. Because, at the worst the wooden frame might bend or get slightly twisted under the stresses. An analogy of a table supported on six or eight legs will make this point clear If one of the legs does not touch the ground, the table will not tilt in that portion.

The disadvantages against these are:

(1) The wooden frame, particularly the exposed members of it, like beams, posts, post-plates, etc., are liable to catch fire In that case the whole structure will collapse.

(2) Certain members of the frame which are embedded into walls do not get free air and are liable to rot by damp or to be infected by dry rot. The wooden frame is also liable to the attack of white ants.

(3) As the economical length of wooden beams is necessarily restricted, long spans of rooms are not possible, intermediate posts must be provided to support the joints in beams and these cause obstruction.

(4) As the entire skeleton forms one unit, noises and vibrations in one part of the building are communicated to every other part.

Since the disadvantages, particularly the first three which are very serious outweighed the advantages, this system came to be gradually replaced by the system of building load bearing walls.

LOAD BEARING WALLS.

This system came into vogue with the advent of steel girders which were light, cheap and capable of spanning longer distances. Walls of either stone or brick in lime mortar were built of sufficient width to bear the load, and rolled steel beams were used for bridging the distance between them. No intermediate supports were required. In fact, posts were used only in open verandahs.

This system however, was found to be uneconomical. The outer walls were required of sufficient thickness to afford protection from the elements and also from thieves. But the interior walls were both unnecessarily costly and occupied large space. Hence, an intermediate system consisting of thick outer walls and frames with thin partitions for inner walls, came to be more widely used.

Of recent years with very common use of reinforced cement concrete as a material of construction we are again going back to the primitive method of frame construction. Reinforced concrete is such a material as overcomes all the main disadvantages of wooden frame construction mentioned above. It is even more fire proof than steel, is also proof against dry rot or white ants, can span any distances and is economical. It further posseses the following additional advantages :—

(*a*) It does not rust like steel, and

(*b*) It provides the only reliable method of construction, so far known, to resist successfully the stresses caused by earthquake, or, air-raids in the days of modern warfare. The technique of building houses to withstand earthquakes and air-raids is slightly different. It is discussed in a special chapter at the end of this volume.

To recapitulate, there are two methods of construction in vogue at present (1) Framework construction with frame members either of wood, steel or reinforced cement concrete and (2) Intermediate system, in which outer exposed walls are thick enough to bear the load, and wooden, steel or reinforced cement concrete frame is constructed inside, to support the load and thin partition walls between the vertical members of the frame instead of thick load bearing walls In either case the exposed walls on the outside require to be of a minimum thickness of 15 inches for reasons already explained.

If frame construction is adopted there is nothing wrong if the wall between the posts or pillars are built of stone or brick in mud or even of sundried clay bricks instead of in lime or cement mortar, for the sake of economy. They should last equally well if a little more attention is given to their upkeep. The only disadvantage is that such walls are subject to damp, attack by white ants and rats. But these can be remedied. The technique of building walls of mud or those of stone or brick in mud, is discussed in detail in the author's "Cheap and Healthy Homes for the Middle Class"

LIME MORTAR *versus* CEMENT MORTAR.

From time immemorial we have been accustomed to use lime mortar as the cementing material. Apparently its cost is so much less than that of cement that the latter is regarded beyond consideration as an economic material for ordinary masonry work. Of late years, there has been a growing tendency amongst engineers to use cement mortar exclusively, instead of lime mortar, on small jobs, costing, say, less than Rs. 1,000/-. But this is mostly from the point of view of convenience rather than of economy. Because building a bullock driven mortar mill and preparing lime in it, or grinding it somewhere in an existing mill and carrying the mortar to site of small jobs, is both troublesome and uneconomical.

However, not only from the point of view of convenience but also from that of economy, cement mortar is far superior to lime mortar as will be seen from the following remarks :—

(1) In the first place lime obtainable is not of uniform quality. Not only does it vary from place to place, but also from layer to layer of the same deposit. It is, therefore, impossible to get lime of standard quality, whereas cement, the manufacture of which is a highly specialized industry, is always tested before it is sent out to consumers.

(2) In the majority of cases the variety of lime used for domestic work is mostly fat* and only partially hydraulic, and therefore, to reduce its shrinkage and prevent its tendency to crack, it is mixed with a certain amount of sand, which, incidentally, makes it porous and facilitates absorption of carbonic acid gas from the air, upon which its strength depends.

* Fat lime is that lime which after burning into kiln, when mixed with water, produces considerable heat and falls to powder with great increase in volume and when it dries up again, shrinks and forms cracks It hardens only by combination with carbonic acid gas from the air and lacks strength Hydraulic lime, on the other hand, neither gives so much heat, nor swells when slaked, hardens in the presence of moisture, and attains considerable strength.

If sand is used in excess, the mortar does not attain its ultimate strength on account of shortage of cementing material.

The writer had once an occasion to dismantle a masonry wall built in mortar of fat lime three months after its construction and he discovered that though the mortar of the plaster had set and become sufficiently hard, the mortar in the interior was progressively weak until that in the centre had simply dried up, without hardening. This was quite expected, because the mortar in such positions as got a better opportunity to absorb carbon-di-oxide from air got hardened and that in the remaining, simply dried up.

At some places the lime, especially that formed by burning nodules of kunker collected from ground surface, contains silica (fine sand) and alumina (clay) and behaves more or less like cement. It hardens in the presence of moisture and attains considerable strength. Such lime would compare favourably with cement in point of economy consistent with strength. Sand is mixed with it mostly to increase its bulk, though it also helps reduce its shrinkage to a certain extent.

Sometimes Soorkhi (crushed bricks or partially burnt clay) is mixed with fat lime which, both gives it slight hydraulicity and also makes it porous so as to absorb more carbon-di-oxide and thus improves its strength.

The stresses coming on walls of houses are usually of compressive nature, i.e., of pressure from the top, and it is found by experiment that a mixture of one part of cement to 15 parts of sand gives as much strength in compression as mortar prepared from average lime and sand in the proportion of one of lime to two of sand, and that the mortar of 1 of cement to 8 of sand compares favourably with that with the best hydraulic lime mortar in proportions of 1 : 2 lime and sand and 1 : 1 : 1 of lime, sand, surkhi.

It will be seen from the calculations made below that 1 : 8 cement mortar costs the same amount as 1 : 2 best lime mortar :—

(Cement Mortar 1 : 8) :—

100 cubic feet of sand @ Rs. 8/- per 100 cubic feet	8	0	0
12½ cubic feet (10 bags of cement @ Rs. 2-4-0 per bag	22	8	0
Bhistie for one day @ Re. 1/- per day.	1	0	0
2 coolies for mixing for one day @ Re. 0-10-0 per day.	1	4	0
Total ...	32	12	0

Rs. 32-12-0 per 100 cubic feet.

(Lime mortar 1 : 2) :—

100 cubic feet of sand @ Rs. 8/- per 100 cubic feet	8	0	0
50 cubic feet of lime @ Rs. 30/- per cubic foot ...	15	0	0
1 pair of bullocks for grinding for 2 days 2 ghanis of 25 cubic feet per day @ Rs. 2 per pair ...	4	0	0
1 coolie for 2 days for filling and emptying the ghani @ 0-10-0 per day.	1	4	0
2 women coolies for 2 days for —do— and holding ghani spoon, screening sand, etc., at 0-6-0 per day.	1	8	0
1 bhistie for 2 days @ Re. 1/- per day	2	0	0
Sundries such as depreciation and repairs to ghani.	0	4	0
Cost per 100 cubic feet. ... ... Total ...	32	0	0

Thus 1 : 8 cement mortar and 1 : 2 lime mortar practically cost the same amount. But the strength of the former is guaranteed while that of the latter is very doubtful. If

fortunately the best hydraulic lime is obtainable and further it is ground well it may be as good as that of the 1 : 8 cement mortar. But in the majority of cases the lime is unreliable and may not develop strength even equal to that of 1 : 17 or 1 : 18 cement sand mortar.

Besides this, cement mortar possesses the following further advantages :—

(1) Even the best hydraulic lime takes 15 days to set, so the work must be carefully watered for at least three weeks. If this is neglected the strength might be very adversely affected. Cement mortar starts setting in about ½ hour and attains considerable strength within three days. It must be watered for about a week. After that if it is neglected the strength would be affected but not to that extent as that of the lime mortar.

(2) Grinding lime mortar is a very slow and tedious process. A certain equipment such as, a mortar mill and bullocks or an engine etc., is required for it. Preparing lime mortar is a very easy thing and can be done very quickly.

(3) Slaked lime deteriorates with time. It is, therefore, possible that the lime supplied may be stale. Again, a large stock has to be made on site. Whereas, fresh cement can be ordered as and when required, since its distribution is very highly organized by the Cement Marketting Co. of India.

(4) The progress of work with cement mortar is very rapid since the mortar sets in a short time, whereas a wall in lime mortar if raised more than 3 feet in a single day, the mortar in the lower joints of it is likely to be squeezed out.

(5) Very strict supervision is required on proportioning and grinding mortar properly and as this process goes on for

months together, almost from the beginning to the close of the building operations—sometimes even by night, it is likely to be slack, e.g. if the grinding is done on daily wages the coolies heap up lime baskets which are light and fill sand baskets only half to save effort as sand is heavy. Thus the mortar is likely to be very rich. Not only does it cost more, but too much lime in mortar causes shrinkage and cracks. If on the other hand, it is done by contract agency the contractor is likely to stint on lime and put sand three or even four times the quantity of lime. Further, the illiterate coolies are very likely to miss the count while filling ghani and a wrong proportion may possibly result. Again, unless some systematic and fool-proof arrangement like a 'tell-tale' is installed, the ghani boy will not make the necessary number of rounds.

If cement mortar is used the following precautions should be taken.

(1) Only thoroughly dry and clean sand should be used.

One cement bag contains 1¼ cub.-ft. of cement. Hence if 1 : 8 proportion of cement to sand is to be used 10 cub. ft. of dry sand should be measured out by taking 4 2½ c.-ft. measures (1′-7″x1′-7″x1″) and spread in a flat heap of uniform thickness and on its to top, a bag of cement should be emptied and an even layer of cement made. This heap should be then mixed three times in a dry state.

(2) The day's requirements of mortar should be calculated and the first thing in the morning that much quantity of dry mixture should be got made in the above manner, in the proper proportion in the presence of a responsible man—mistry or moocadam. The heap of this should be kept apart on a dry platform and a quantity just enough for half an hour's requirements should be taken from it at a time

and mixed with water twice on a different platform *away* from it and used on work within half an hour.

(3) Masons should be instructed to use mortar carefully, so that the least quantity drops down on ground by the sides of the wall. Still arrangements should be made to spread a piece of bamboo matting or gunny bags and a young boy should be specially employed to pick the mortar from it every 15 minutes and put it into the mason's baskets.

WHETHER TO BUILD IN STONE OR BRICK.

Very often a layman is confronted with this problem. The following discussion will help him in making his own choice.

Obviously stone is stronger and more durable than brick. But unlike public buildings of monumental nature such as city halls, municipal and post offices, banks etc., no one expects his home to last for more than 200 years and yet we see brick buildings built 200 or 300 years ago still surviving in good condition. This leads us to conclude that brick also is sufficiently strong and durable for our purpose.

As protection from thieves and house breakers, brick walls behave equally well or perhaps better than stone walls. For, if the mortar is good its adhesion with brick is so strong that to make an opening into a brick wall small pieces of brick have to be chipped and this cannot be done without considerable noise and a severe shaking.

Brick offers greater facility for ornamental work in plaster, as a rough shape can first be given to the brick by means of an axe and finishing could be done in plaster. That is not so with stone. It must be finely dressed for ornamental effect at great cost. Plaster does not stick so well to stone as to brick.

Brick is a very suitable material for corners of walls on account of its rectangular shape. Even for jambs of doors and windows and for circular or hexagonal windows requiring an obtuse or an acute angle brick offers far greater ease and convenience than stone.

A brick wall requires a fixed quantity of mortar and on account of its flat surface there is less possibility of hollows being left in it than in a stone wall, at the hands of careless masons.

It is possible to build walls of any thickness—from 3″, $4\frac{1}{2}$″, 9″ to 14″ and more in brick, whereas the minimum thickness of a stone wall is 15″. This is on account of the large and irregular shape of a stone.

A brick wall of 14″ thickness can support a building of two storeys height, whereas for the same, a minimum thickness of 18″ is required for a stone wall.

Further, brick does not absorb so much heat as stone—a matter of considerable importance in tropical countries, where the problem of mitigating heat inside rooms for comfort has to be faced.

The disadvantages of brick are :—

It absorbs moisture and is liable to make the house damp. With damp certain salts also rise into the wall and these salts cause disintegration of brick.

Brick cannot be allowed to come in contact with urine or sewage for the above reason. Hence in such places it must always be covered under cement plaster.

Bricks manufactured in India are not generally of a very good quality like those in England. Their colour is not uniform, nor their outer skin sufficiently resistant to the piercing rain. It has, therefore, to be plastered on the outer surface, which increases its cost.

From the above discussion it will be seen that for practical purposes brick is as strong and durable as stone and possesses, in addition, several advantages.

Thus there are only two things which should determine the choice :—

(1) *Individual taste.*—A stone building is strong and reflects strength in every inch of it; it is in tune with Nature; its colour not only does not fade, but improves and looks

more serene with age; stone has history of ages behind it. Whereas brick is an artificial product manufactured in imitation of stone, it is a flimsy material and plastering is only a camouflage to cover its defects; and to give a mass effect cement plaster in imitation of stone is admission of its weakness.

(2) *Economy.*—This should, in fact, be the determining factor. If economy is the criterion the following calculations are required for instituting a fair comparison.

As already explained above, a 14 inch brick wall will do very well where a stone wall of 18 inches thickness is required *i.e.*, within the same volume of masonry, a longer wall in brick can be constructed than in stone. Hence the rate of brick wall must be reduced in the proportion of 14/18 for comparison. But brick work requires plastering on the outside and out of 100 cubic feet of brick masonry we can have a wall surface of $\frac{100\times12}{14}=86$ sq. ft. So add to the above, the cost of 86 sq. feet of plaster to arrive at a rate for comparison with that of stone masonry.

Example. 1—In Poona the rate of brick-in-lime mortar or brick in (1:8) cement mortar is Rs. 45/- per 100 cubic feet and that of cement plaster is Rs. 10/- per 100 square feet while that of stone masonry is Rs. 35/- Which is cheaper?

Rate of brick work $-45\times\frac{14}{18}=$ 35 plus cost of plaster

$86\times\frac{10}{100}$ Rs. 8-10. Total Rs. 43-10-0.

Against the rate of Rs. 35/- of stone work. In this case, therefore, stone masonry is cheaper.

Example. 2—In Calcutta the rate of brick work in lime mortar for superstructure is 33 rupees per 100 cubic feet and that of exterior sand plaster is Rs. 4-8-0 per 100 square

feet; while the rate of coursed rubble stone masonry in lime is 33 rupees per 100 cubic feet. Which is cheaper?

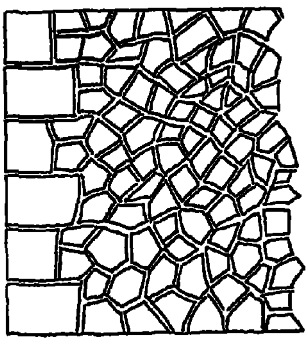
Equivalent rate of brick work. 33 x 14/18	Rs.	25	10	0
Plus cost of 86 sq. ft. of plaster at Rs. 4-8-0	...	3	14	0
Total	Rs.	29	8	0

This is less than the rate of Rs. 33/- per 100 cubic feet of stone masonry. Hence brick work is cheaper.

WHAT TO LOOK FOR STRENGTH IN STONE MASONRY.

Stone masonry, as employed in walls of building, is either of coursed rubble or uncoursed rubble variety. These varieties are caused according as how the masonry looks on the main or exposed face. The back face in both the varieties is uncoursed as it is usually covered with plaster.

(1) Coursed rubble masonry (Fig. 30) has face stones dressed to a rectangular shape of uniform height or thickness and are laid in rows or courses and thus you see long, parallel lines of horizontal joints with vertical joints at right angles to them. There are a number of further varieties in this, with costs varying according to the fineness of dressing both on the face and sides.



FACE WORK OF UNCOURSED RUBBLE MASONRY

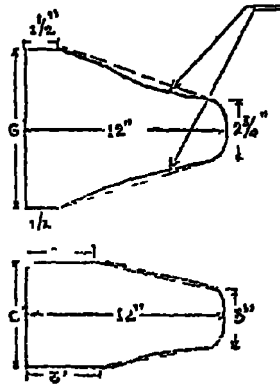
Fig. 21.

(2) Uncoursed rubble, sometimes called random rubble masonry, on the other hand, presents irregular joints on the face, which are neither parallel to, nor at right angles to each other and thus there are no regular courses. In this variety also there are a number of further sub-varieties such as first, second and third class work according as the fineness of dressing, uniformity of size of stones and fineness of joints.

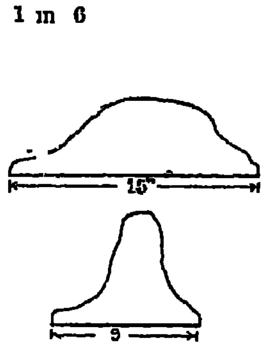
In both the coursed and uncoursed varieties back surface, which is usually hidden under plaster, is made of 2nd or 3rd class uncoursed rubble masonry with no attention to appearance. see fig. 31.

Points to be noted for strength in both the varieties.

(*i*) Fine dressing on the face of stone does not help increase the strength. It improves the appearance only. Hence, if strength is desired the face stones should be so dressed that each one of them will get a flat surface of at least three inches to rest upon each other behind the face as shown in fig. No. 23. Masons are in the habit of chipping off edges of stones with a hammer, leaving ½ inch or less flat joint back from the face as shown in figs. No. 24 & 25

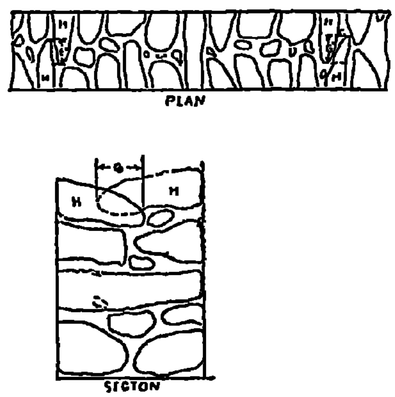


Figs 22 & 23
Plan & side view of a good Khandki



Figs 24 & 25
Bad Khandkis

(*ii*) There should be long stones going *through* the wall from one face to the other (called "headers") at least 6 feet apart in each course. They should preferably have two faces as shown in figure Nos. 26, 27 & 34 If, however, such stones are very costly two single faced shorter headers should be of such lengths that when placed on opposite faces their tails should overlap each other at least 6 inches as shown in figs. 26 and 27.



Figs 26 & 27 Plan & Section of a Wall
Two-faced through header & two single faced short headers with tails over-lapping

(*iii*) The filling should be made with as large stones as possible and not by small chips and the stones should be selected of such a shape and should be so laid as to fill the hollow and to rest solidly on or between the tails of face stones on

either side, so as to bind both the faces together as shown in fig. No. 27. In the absence of proper supervision careless masons are apt to construct a two face wall with no bond between the two faces as shown in fig No. 34 (2).

(*iv*) Every stone should be wetted with water before it is set into masonry. This causes the mortar to stick to it better.

(*v*) The work should be started from one end on both faces of the wall together at the same time. Some masons are in the habit of laying a long line of face stones on one side, then doing the same on the other and then filling stones and chips between both the rows of face stones. This is likely to result in a wall with no proper bond between the two faces as described in (*iii*) above. (vide fig. 34 (2))

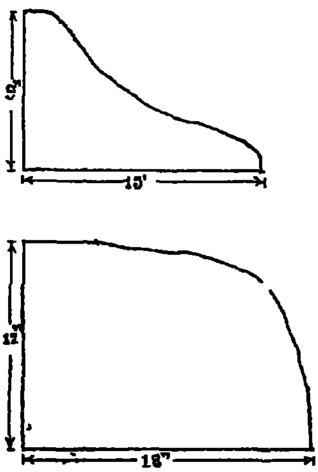


Fig 28 & 29
Bad & good corners respectively

Some masons are in the habit of filling stones and small chips dry in the beginning and then pouring basketfuls of mortar made thin on the top which enters some of the crevices. This is a dangerous practice. In the first place it leaves a number of hollows inside the wall. When the ultimate full load comes on the wall the chips on the top of these hollows are likely to break under the load and cause a crack on account of settlement. Secondly, too much water in mortar is bad, for, when the water evaporates its place is taken by air, *i.e.*, it becomes a hollow or honey-combed and not a solid wall.

(*vi*) The proper way of laying masonry of wall is—

(*a*) to first mark the positions of the headers and place them there.

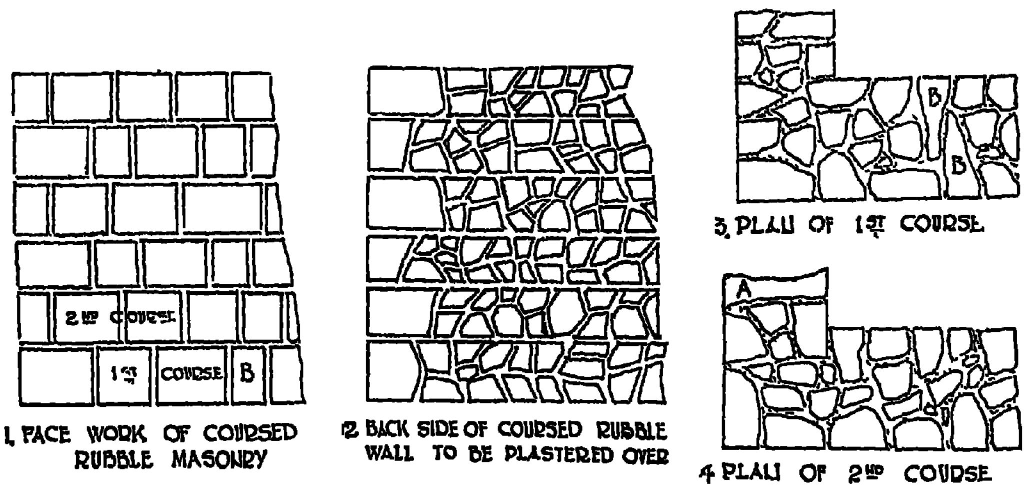
(*b*) to sprinkle water on the surface.

(*c*) to spread fairly stiff mortar about ½ inch thick and lay a face stone, put mortar by its sides and similarly lay another face stone by its side, thus lay 2 or 3 face stones on each face correctly in a plumb line.

(*d*) as soon as a stone is laid on mortar bedding, whether on the face or in the interior for filling, it must be struck with a hammer with medium force.

(*e*) after the face stones are laid, fill in mortar on their sides and insert chips of stone to pack them solidly.

(*f*) then spread fairly stiff mortar in the interior and lay stones previously wetted each under a stroke



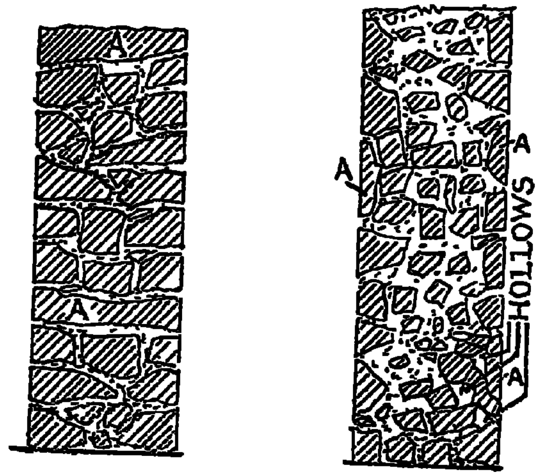
Figs. 30, 31, 32 & 33.
B, B in (3) are short headers overlapping each other.
A in (4), Double faced through header.

of hammer, for the filling. The stones should be as large as possible and should be so selected as to fill the hollow and at the same time serve to bind both the faces together. It does not matter if the stones used in filling are slightly thicker and so rise above the thickness or height of the course. No

attempt should be made to make the top level by using small chips.

Additional points to be noted in *coursed* rubble masonry :—

(*vii*) The khandkees (rectangular faced stones) should be dressed to at least 2 inches behind the face edge to form a flat junction with the khandkees both below and above it.



1. GOOD WORK 2. BAD WORK

CROSS SECTIONS

Fig 34

A, A in (1) are double-faced headers
A, A, A in (2) should have been laid on the flat surfaces.

(*viii*) The face stone should tail *i e.* go into the thickness of the wall at least to a length equal to its height and at least one third of the face stones should tail twice their height.

(*ix*) The vertical joints should break with each other *i e.*, they should not be one above the other to form a continuous joint or close together.

Additional points to be noted in *uncoursed* rubble masonry :—

(7) Every stone should be laid with its flat surface down and not on the edge. Most masons are apt to do this mistake, if supervision is slack. They lay the stones as shown in fig. No. 34 (2) in which stones Nos. A. A and A should have been laid on their flat surface. They are 9″ to 14″ high but they tail or go only 4″ to 6″ into the wall. They are thus likely to slip out under the upper weight.

BRICK WORK.

The tests which a layman can apply to distinguish good brick from bad are:—

(1) It should be fairly heavy and if allowed to drop flat from a height of 3 feet on a hard ground should not break.

(2) It should not absorb more water than 1/5 of its own weight if kept immersed for two hours in water.

(3) It should give a clear ringing sound when struck.

(4) Five or six bricks selected at random should be kept immersed in water overnight. If they fall to pieces or show fractures or cracks they should be rejected. Such bricks have particles of lime kunker in its clay and when burnt these particles form lime. When such bricks containing lime slakes after contact with water and swells the brick cracks or falls to pieces.

The above are important tests. Other minor tests are:

The colour should be uniform, but this is not a reliable test. The edges should be sharp and the surface flat *i.e.* not bent but if brick work is to be plastered these are unimportant, provided the bricks are well burnt. Even overburnt bricks are not bad for 2nd class work. Underburnt should, of course, be at once rejected.

The thickness of bricks varies from $1\frac{1}{4}''$ to $3''$. The thicker should always be preferred as in that case less mortar is required and the number of joints being reduced, work is quicker and also cheaper.

Points to be noted in brick work.

(1) Bricks should be kept immersed in water for at least two hours before use. Workmen often dip them into water and at once remove them. The result is that they

absorb moisture from the mortar and the latter does not set in consequence.

(2) No bats or half bricks are to be used.

(3) The joints should be thoroughly grouted with slightly thin mortar. As bricks are absorbent there is no harm in using thinner mortar unlike in the case of stone masonry where fairly stiff mortar must be used.

PARTITION WALLS.

The function of a partition wall is to divide a large room into two or more small rooms and to afford privacy.

As partition walls are not expected to take up any weight except their own, they need not be thick.

Privacy is of two sorts (1) that of sight and (2) that of sound. For the first, a thin partition about 7 feet high, even a cloth curtain, will do, but to accomplish the latter object, it is not so easy.

The modern trend is to build outer walls strong and thick enough to bear the load of the house and also to give protection from thieves and inclmency of weather, and to construct all the inside structure of frames to support the load and build partitions between bays of the frame to divide the space enclosed by the outer walls into small rooms.

The following are the different kinds of partitions made:

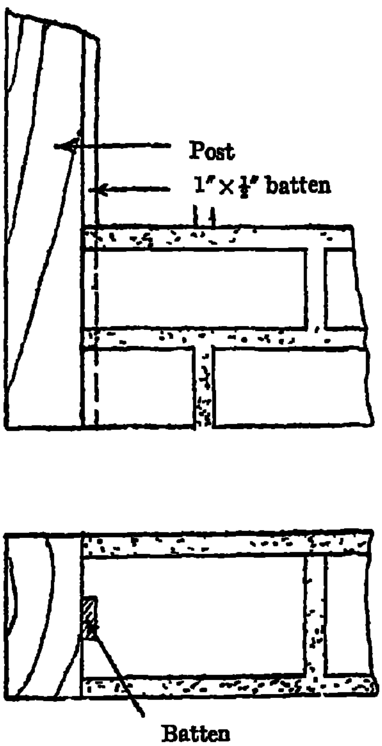
(1) Partitions of brick-nogging with wooden frame work for holding the brick work in position.
(2) Reinforced brick partitions.
(3) Lath and plaster, and Hy-rib partition.
(4) Wooden partition.
(5) Armoured plywood and fibre board partition.
(6) No-frango partition.
(7) Glass partition.

(1) Partitions of brick-nogging.

These may be either $4\frac{1}{2}''$ thick including plaster on both sides with brick laid on edge in cement mortar, or $6''$ thick with brick laid flat and plastered over on both sides. As the brick work is very thin it cannot stand alone, without some frame work These kinds of partitions are universally in vogue, with wooden frame work. But they are not satis-

factory for several reasons *viz.* (*a*) that they are by no means light since the whole load is concentrated on a narrow base and thus the intensity of load is the same as that of a thick brick wall. This requires deep foundations and further these sorts of partitions cannot be used on the upper floor unless they are supported from below by either a wall or a heavy beam. (*b*) Since mortar does not stick well to wooden frame work, the brick work becomes loose between vertical members of the frame. (*c*) Since only sound and whole bricks are required and it has to be plastered on both sides the cost is heavy.

To remedy the defect (*a*) instead of filling foundations from the lowest level, beams of rolled steel joists encased in cement concrete or of R.C.C., may be made with their ends resting on the masonry of thicker walls with their top flush with that of the plinth and the partitions built over them. This method is cheaper only if the foundations are more than 3 feet deep. To remedy (*b*) frame work of thin section of T-iron may be made. Cement mortar sticks very well to steel and thus there is very little possibility of the brick work being loose. However, in no event should lime mortar be used, as lime has a destructive effect on steel, or if wooden frame work is to be used, battens say, 1″ x ½′ may be nailed vertically in the centre of the vertical members of the frame work and while laying bricks there, a corresponding notch should be cut into one end of the brick so that the batten



Figs 35 & 36.

will hold it firmly in position (see figures 35 and 36) and prevent it from becoming loose.

Objection (*c*) is unavoidable.

(2) **Reinforced brick partition.** This is similar to bricknogging described above except that instead of horizontal pieces of wood forming members of the frame, either ¼" diameter iron rod or a thin iron strip about 1" wide and 1/16" thick is laid in cement mortar in every 4th or 5th layer between the two side supports which may be up to 12' apart. If the side supports are of masonry, the ends of the iron bar or strip may be thrust into them at least 3 inches. If they are vertical timbers the bar can be thrust into holes about one inch deep and if they are iron strips, about one inch length of their ends may be bent at right and nailed to the posts.

(3) **Lath and plaster and Hy-rib partition.** The lath may consist of split bamboos or thin battens of any wood provided there is no possibility of their being attacked by white ants. Teakwood is not attacked, but it would make the partition very costly. A frame work of wood say of 3" x 2" verticals and 3" x 1½" horizontals should first be erected and then rough trellis work of split bamboos may be diagonally laid between battens nailed to the frame. The glazed skin of the bamboos should be inside and rough side exposed. This should be plastered with either cement mortar or lime mortar, in which a little cement is mixed.

For expanded metal partition 3/8" diameter round iron rods are placed vertically about 15" apart with their ends inserted about half to one inch into both the floor and ceiling. To these are then tied by wire expanded metal sheets 3/8" diamond mesh, and ½" cement plaster is laid on each face. Before plastering on the first face a temporary support in the form of a flat board, such as that of asbestos cement sheet must be given.

Hy-rib partitions. Hy-rib sheets are obtainable 6 to 12 feet long by 10½″ wide. They are something like corrugated iron sheets with diamond shaped holes cut into them See Fig. 37. The corrugations are 13/16″ inch deep and 3½ inch apart running lengthwise. For partitions the hy-rib is erected with the ribs vertical The joints are made by interlocking the edges together and punching them by a special tool supplied with the hy-ribs and plastered over with cement mortar on each face like the expanded metal partition.

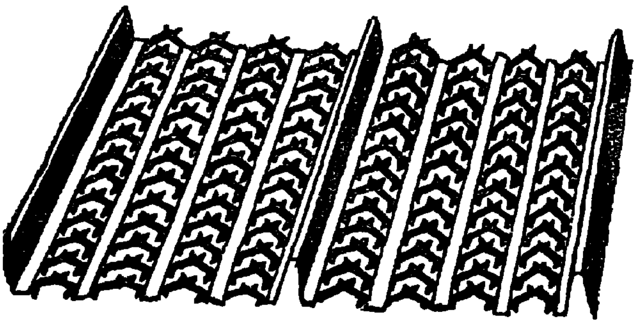


Fig. 37
Hy-Rib.

(4) **Wooden partitions** are no longer in common use on account of the high initial cost, and subsequent opening of the joints due to shrinking of wood, which harbour dust and vermin and of the liability to catch fire.

(5) **Armoured plywood and fibre board partitions.** Wooden frame work is first erected and large sheets of plywood with a sheet either of galvanised iron or copper cemented to one face are nailed or screwed on to it on both sides. The joints which are few are protected by special moulded and metal covered strips. Ordinary plywood bends and buckles and is not suitable for partitions unless very close framing is made at great cost. There are numerous varieties of fibre boards available in the market notably asbestos cement sheets, celotex, etc. The hollow space between them which may be from 1½″ to 3 inches wide depending upon the thickness of the wooden framing, may be filled with either some fibrous or granular material such as rice husk and sand, or cut grass or sea weeds, coal ashes, rock wool, wood shavings etc. treated

with some cement. In that case it becomes a sound proof partition also. Instead of fibre sheets pressed wood sheets like masonite may be used. Though more costly, they are stiffer and require less framing and further their natural colour is so good that the partition need not either be distempered or painted.

(6) **No-frango partition.** This is a cheap but very satisfactory variety of partition. For this wooden frame work is first erected and then jute or hessian cloth of wide mesh previously wetted with water, and then in cement grout, is stretched well and nailed on one face. Then a grout prepared with one part of cement to two of fine sand mixed in water should be applied to it by means of a brush on both sides. While this coat is still wet it should be plastered with mortar of one part of cement to three parts of coarse sand and when this coat sets sufficiently another coat of mortar in the same proportion but with finer sand should be applied. Both these coats should be together about 1 inch thick. This should be repeated on the other face of the frame work, leaving about 1½" to 2" hollow space between, which may be filled if necessary with some such material as described in the previous method.

(7) **Glass partition.** Consisting of wooden frame work with panes of glass fixed as usual for glazed windows. The panes may be either of frosted plate glass so as to make them opaque or of wired glass, which has the further advantage of being splinter-proof. As large panes as conveniently possible should be used.

Glass partition can be given any decorative effect, it transmits light and further it is more sound proof than any other partition of that thickness, but it is very costly and is liable to break.

DOORS.

After the plinth masonry is completed, the first thing to be done before the masonry of the superstructure is commenced is to erect the door frames in positions, both in the main and the partition walls.

The scantling to be used for door frames in the main walls should be a minimum of 4" x 3" and that of the doors in the partition walls should have one dimension equal to the thickness of the partition including plaster, particularly if the latter be of brick-nogging. For instance, if the partition be half a brick thick *i.e.* six inches including the plaster, the door frame should be 6" x 2" to 3". If this is not done, the projecting corners of the plaster are sure to be knocked off every now and then.

The modern trend is to omit the bottom sill of door frames. This facilitates the sweeping and the washing of the floors and also removes obstruction. But a difficulty is caused in opening and closing the shutters if a carpet or coir matting is spread on the floor across the doorway. If, to avoid this difficulty, the door shutters are raised above the floor by an inch or so, an unsightly gap remains, through which not only sound may be communicated to the outside, but rain water from exposed doors might come in and further, the gap might give passage to vermine and small rats and even to reptiles.

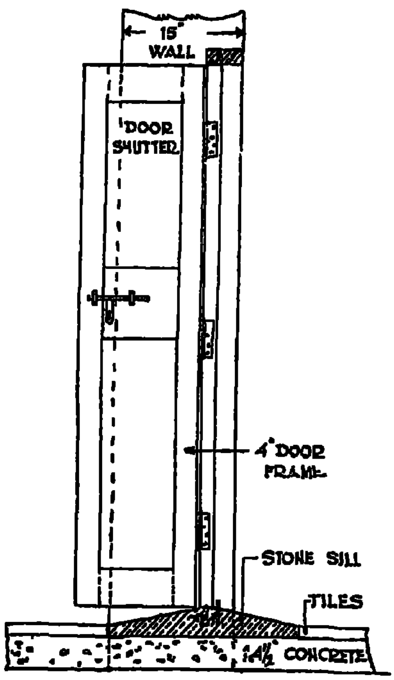


Fig 88.

To remedy this, a row of tiles may be laid on the top of concrete across the door way to give a raised sill of the width of the shutter and one inch above the general floor level with slopes on both the sides or on the inside, if the door be in an exposed wall, as shown in figure 38. The shutters open easily over a mat or a carpet and this form of the sill is extremely convenient when washing or sweeping the room. Finely dressed stone sill or a flagstone sill may also be laid in which holes required for the shutter bolts are quite durable. In a tile sill brass bolt eyes may be fixed into the holes with molten lead. When the bottom piece of a door frame is omitted a piece of iron rod 5/8″ to ¾″ preferably square in section should be thrust about 3 inches in the bottom of the vertical members of the frame and projecting about 2 inches and this projection should be embeded into the cement concrete (see fig. 38 & 54).

Size of doors should vary according to its use. Thus the main entrance should be between 3 feet to 4′ 6″ by 8 to 9 feet high including ventilator. In every important room at least one door should be wide enough to allow heavy pieces of furniture, such as sofas, tables, beds, almyrrahs etc. to be easily carried through *i.e.* 3 to 4 feet wide and as a general rule, no door, except those in W. C. and urinal should be less than 2′ 6″ wide and 6 feet 3 inches high inside the frame to avoid accidents. The doors of W. C. and urinal may be 1′ 9″ to 2′ by 6 feet. The bath room door requires to be at least 2′ 6″ to enable a bath tub, hot water boiler or a dressing table to be carried into it. The height of doors thus comes to 6′ 6″ from the bottom to the outside of the top piece in the case of doors without ventilators and to 7′ 9″ to 8′ 3″ according as the height of ventilators is 1 foot or 1 foot 6 inches.

Ventilators on top may be provided to all doors in the exposed walls and those opening into verandahs so as to

admit fresh air and to none in the inner or partition walls.

Every frame, whether of a door, or a window should be examined by means of a carpenter's square to ensure that the angles are correct right angles and should be carefully laid in position by means of a plumb bob and this should be tested and set right from time to time until it is firmly set at least in 3 feet height of masonry on both sides, as it is likely to be disturbed by something striking against it

The part of the frame which is likely to go into or be hidden by the masonry should be given a thick coat of hot coal tar before the frame is erected.

In order that the frame should not become loose or shaky by the bangs caused by the opening and closing of the doors, wooden pegs about 6″ long are sometimes driven at right angles to the sides of the frame and embeded into the masonry. But they are not satisfactory. Instead, straps about 1/8″ to 3/16″ thick and one to 1½″ wide should be bent as shown in figure 39 and one end of them nailed to the frame and the other embedded into the masonry.

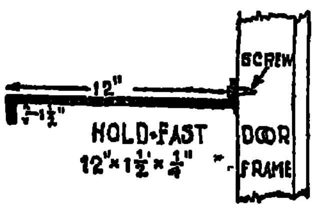


Fig 39.

In India even narrow doors are provided with two-leaved shutters. In England, on the contrary, even the main doors are provided with single leaved shutters. Both systems have their own advantages as well as disadvantages. The best course is to adopt single leafed doors for all partitions and double leafed ones for those in thick walls. With a single Leafed door there is a saving in the hinges and other fittings and also in labour. They further occupy the least space when they are placed in a corner and open against a wall.

If partition walls are thicker than 6 inches it is advisable to use parliamentary hinges by means of which the shutters will open flat against the partition wall and leave the entire door opening clear.

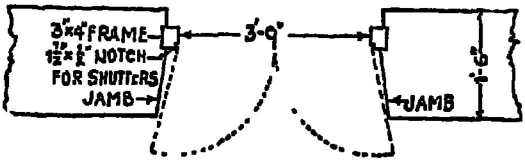


Fig. 40.

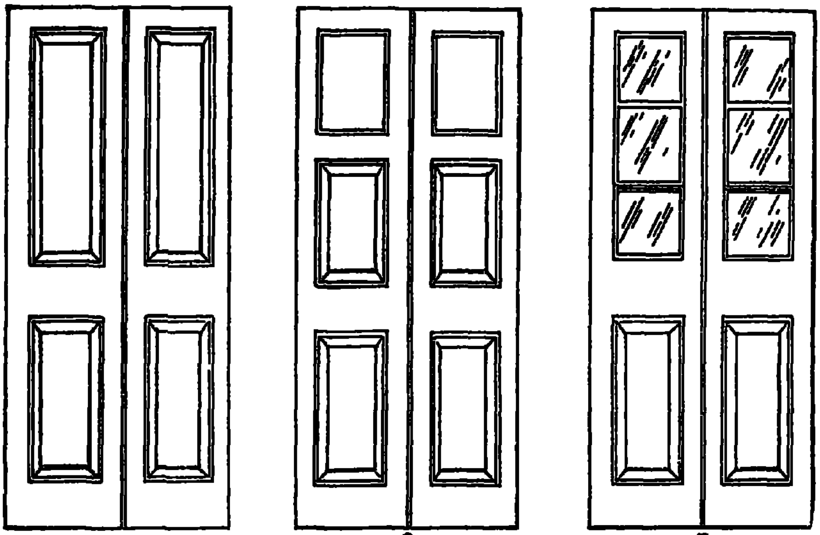
Jambs. The vertical sides of door and window openings are usually kept sloping at from 1 in 4 to 1 in 6 as shown in figure No. 40. These are called jambs.

The shutters of doors are made of various types such as panelled, half panelled and half glazed, plane-planked, planked and braced, false panelled etc. In fact the cost of a door is dependent on the particular variety chosen. These are shown in figures 41 to 44. The modern trend is to adopt flush panelled doors *i.e.* on both the faces the shutters present a plane surface with neither a projection nor a recess which accumulates dust. Figures No. 45 and 46 show flush panelled doors. The lines showing rectangles are painted.

The door fixtures and fastenings such as hinges, tower bolts, aldrops, locks, handles etc. were formerly made either of steel or brass. Steel is liable to rust and brass is very costly as it requires continually to be polished every now and then with the application of metal polish. The trend of modern architecture is to adopt such materials and such designs as will save labour. From this point of view these are used in modern times of either stainless steel, oxidised steel, oxidised brass or nickel or chromium plated steel or brass. If economy is desired, nickel oxidised steel is the cheapest but in course of time it is liable to rust, the next best being oxidised brass. This material does not require any attention. The best is of course chromium plated steel or brass which presents a silver like shining

appearance for an indefinite time with very little attention, but it is a bit costly. Handles made with a combination of

Figs. 41, 42 & 43



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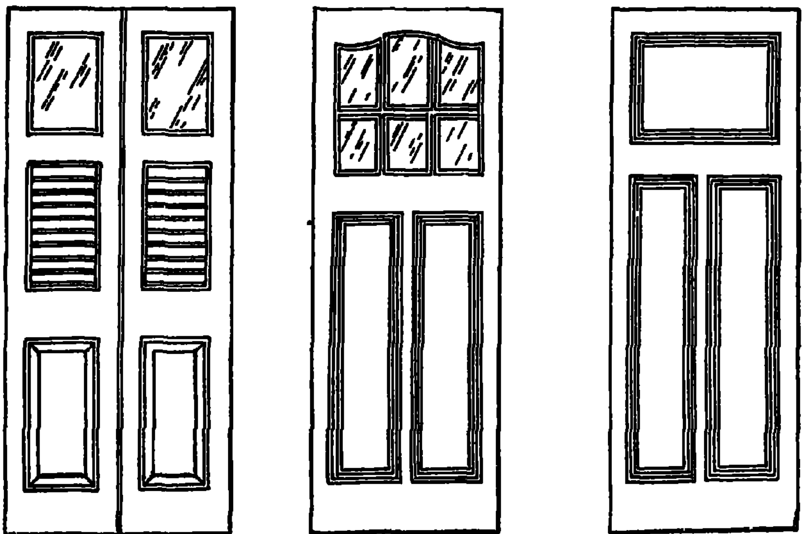
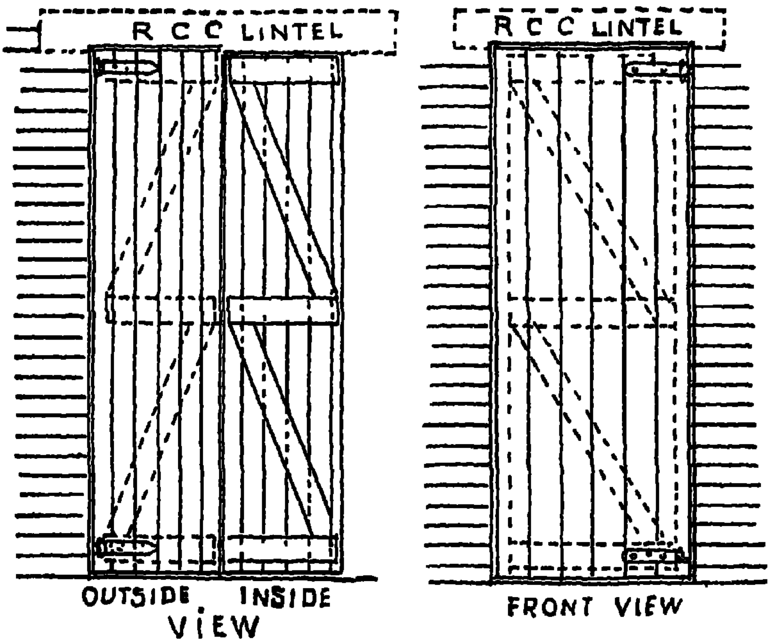


4 5 6

Figs 44, 45 & 46.
Doors 5, 6 are flush panelled

bakelite in various pleasing shades and designs and chromium plated steel are available in the market at reasonable prices to match the general colour and decorative scheme.



Figs. 47, 48.
Doors framed and braced.

WINDOWS.

Windows serve the double purpose of supplying light and ventilation. It is likely that in future when air conditioning will become very common and come within easy reach of middle class people, their function will be only to supply light and thus they will be very few, required only in such apartments as dressing and office rooms.

At present, however, the more they are in number the better. Over-ventilation does no harm but under-ventilation is positively full of it. Hence, not only windows but other means such as bull's eyes, clerestory openings, roof ventilators etc. should be provided, so that when the windows are closed through ignorance or for fear of draft, full amount of fresh air will still be coming through these openings.

As far as possible they should be so arranged that cross currents of fresh air should traverse through the rooms.

The old system of providing stout iron bars in windows for protection against thieves, which gave an appearance of a prison to domestic houses is gradually being replaced by wrought iron ornamental grille work of either ½" to 5/8" square bars or strips ¾" to 1" wide 1/8" thick. Simple designs which admit of easy cleaning should be adopted.

It is usually convenient to keep the top of doors and windows at the same level. This restricts the height of windows, since the minimum height of doors is fixed. The bottom of window should be at 2′ 6″ to 3 feet above the floor level. However, if window seats are required they may be kept at 1′ 6″ to 2′.

The space below window sill can be utilised for a cupboard at a cheap cost, since the window sill forms the lintel on the top of the cupboard and thus no extra expense is required for it.

A projecting cornice is usually provided on the exposed side of the window sill both for appearance and for allowing the rain water to flow away from the wall. For the latter purpose it should have a good slope on the top and throating underneath as shown in figs. 16 & 49.

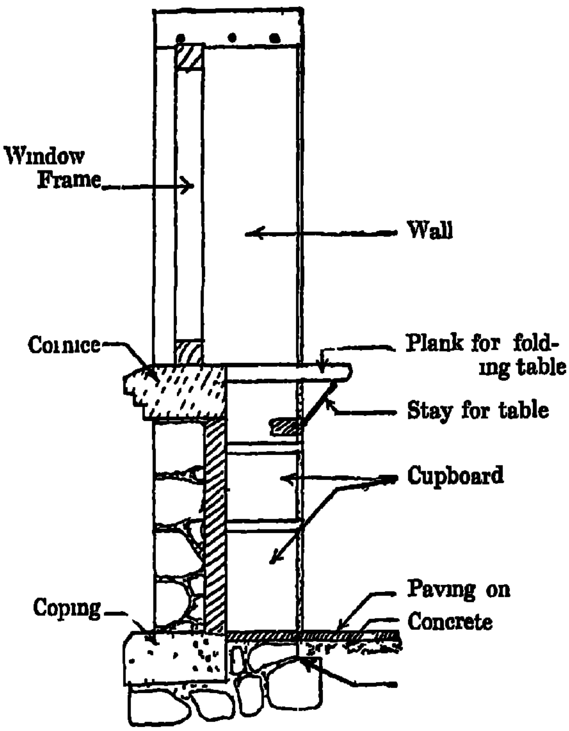


Fig 49.
Section through a window
A cupboard is formed below window sill, with a folding table.

In order to exclude rain and also excessive glare when the sun is high at an angle, weather shades on the top of windows are required. The modern trend is to provide flat R. C. C. canopies extending about 2 to 3 feet beyond the wall. In so far as they do not obstruct light they are infinitely superior to the ordinary sloping weather shades of old time.

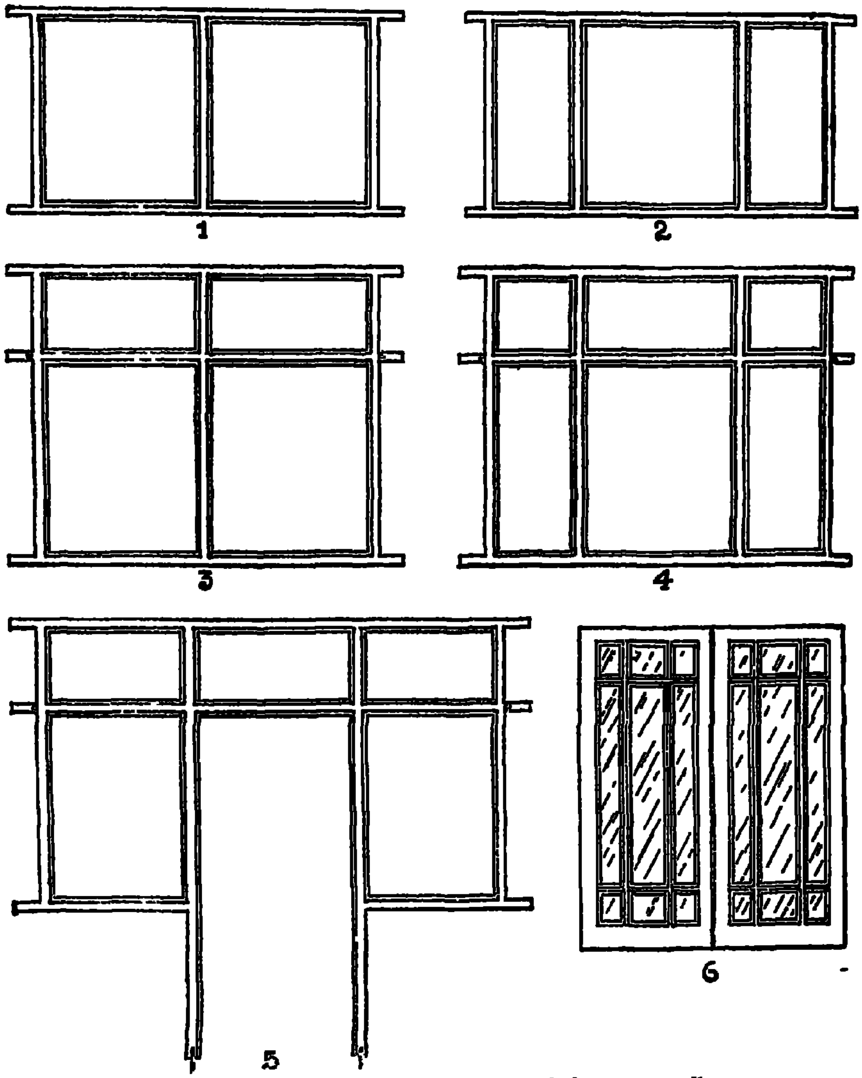
Regarding the size of windows all depends upon individual choice. 2′ x 3′, 2½′ x 4′, 4′ x 5′, 5′ x 6′, 5′ x 8′ are some of the sizes which look well. However, it is difficult to lay down in general terms which size of windows will look well. It must suit the general outline and architecture of the particular building. With modern architecture there is a general tendency of providing wider windows such as 6 feet long by 5 feet high or 8 feet long by 5½ feet high as shown in figs. 50 to 55. It is desirable to provide ventilators on top of windows as in figs. 52 to 54.

The shutters of windows in the exposed walls should open on the outside and parliamentary hinges should be used for

Figs. 50, 51

52,53

54, 55



Frame No 5 is suitable for an entrance to a balcony or gallery

them on the ground floor so that they should open flat against the walls.

Venetian shutters, which harbour dust and vermin and are difficult to clean, are out of taste in modern days.

With modern designs projecting window sills to form R.C.C. boxes as in front of windows and grow dwarf varieties of flower plants in them is commendable.

WALL-CUPBOARDS.

Cupboards are a great asset in a home. The smaller the home, the greater is the necessity of wall cupboards. A portable wardrobe or almyrrah costs a minimum of fifty rupees. Moreover not only does it occupy some space of the floor area, but it also lends a flat surface on its top for lodgment of dust which is full of harmful bacteria. A wall cupboard on the other hand, not only does not take up floor area, but being inside a wall gives some extra space, it costs only about twenty-five rupees at the most and is absolutely free from the last named disadvantage of dust. Every wall cupboard, should, for this reason be provided with close fitting shutters, howsoever of cheap material they may be.

Too many cupboards, however, cause great inconvenience. The positions of beds, and other furniture should first be decided and cupboards should be provided in the remaining space.

In order that a cupboard should be of maximum utility it should be as deep as possible. It is possible to have a cupboard even 12 inches deep in a 14-inch brick wall. If a three inch wall is built with bricks on edge behind a cupboard and as an additional safety, thin paving slabs, say, ¾ inch thick are laid vertically to line the inside of the cupboard, about 10 to 10½ inch depth is easily obtainable and further, such cupboards if constructed even in the exposed wall they can be safely utilised for storing valuables. For, even if a hole is attempted by thieves by pulling out bricks, it is impossible to cut a hole in the paving slab behind it without making considerable noise.

The depth of cupboards can still further be increased by lining the back on the inside with ¼ inch cement asbestos sheet or masonite.

Better still, do away with the 3″ thick masonry as described above and lay instead one inch thick paving slabs of as large a size as possible on edge. Slabs with very rough surface which makes them unsuitable for paving are very useful here These should further be reinforced on the outside by two ¼ inch iron rods laid vertically and two to four horizontally with their ends embedded into the brick masonry and wired to each other at points of crossing. Mortar of coarse sand and cement should then be screeded against the surface and when this is hardened, on the rough surface presented by it, cement plaster be laid as usual. This makes a strong and durable wall of only 1½″ inch thickness behind a cupboard and affords maximum depth for storage.

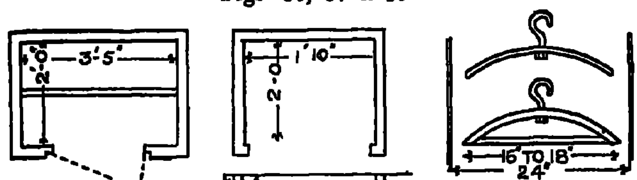
The size of wall cupboards depends upon individual liking. However, the width should be between 2½ to 3 feet and its bottom should be at least six inches above the floor level. The top shelf should not be higher than say 5′ 9″ above floor so that a person of medium height should easily reach it with his hand.

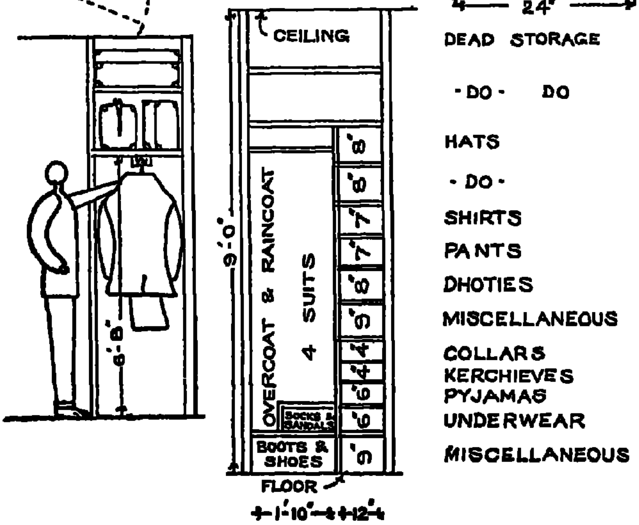
There should be four or more rows of shelves in it, the lowest shelf should be 1′ 3″ high so as easily to accommodate bulky and heavy things and tall bottles. It is desirable that battens should be built into the sidewalls inside the cupboards projecting about ¾ inch outside the plaster and the shelves should simply rest on them to facilitate their easy withdrawal for cleaning.

Besides these wall cupboards for storing odd things, " clothes closets " may be provided one in each bed room either outside a wall or partly in and partly outside, so as to give a depth of 20 to 22 inches. Half the vertical space in it may be utilised for hanging suits, pants and overcoats etc., if for gents, and sarees, if for ladies and a number of shelves may be made in the other half for folds of other clothes. One such closet in

each bed room should obviate the necessity of hanging clothes on pegs on walls. Even shoes and sandals can be put there. These closets should be carried up to the ceiling level and separate shutters and shelves should be provided above 7 feet height for storing articles of dead storage suchas travelling kit etc. which are required only occasionally. Thus a very large space which would otherwise have been wasted can be very conveniently utilised. A sketch of such a closet is given in fig. No. 56 to 60.

Figs 56, 57 & 58





Figs 59 & 60

A hollow partition of 2 ft. depth between two adjecent bed rooms would afford one such clothes closet inside it on opposite sides in each bed room.

LINTELS.

The opening for a door, window or a wall cupboard must be bridged across to carry the load of wall etc. above. This is done either by a lintel or an arch.

A lintel may be either of (1) wood, (2) stone, or (3) reinforced concrete.

(1) Wooden lintels are now-a-days scarcely used as they are costly, liable to catch fire and susceptible of being attacked by white ants and dry rot. They are 3 to 4 inches thick for ordinary openings up to 4 feet wide.

(2) Stone linlets, on account of their initial cost of quarrying, carrying to site dressing finely and lifting to lay in position, are also scarcely used except in some parts where such long stones are cheap and abundant. Still even there they are rapidly falling out of use, since long lengths suitable for modern wide windows are not available except at prohibitive cost. Besides R. C. C. lintels are so cheap, and convenient to make, and reliable that they are preferred to stone lintels even on small spans.

(3) R. C. C. lintels.

For lintels over openings up to 4 ft., 3 iron bars of 3/8 inch diameter should be bent as shown in figure 63 at 1, 2 & 3.

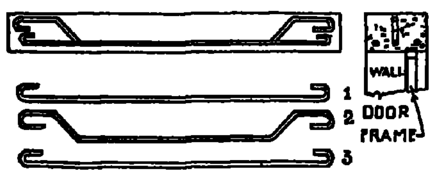


Fig. 61, 62, 63.

They should be spaced so that two of them lie at 2 inches from either face of wall and one in the centre; across these should be placed at equal intervals, 3 or 4 pieces of ½ inch bars each of length equal to the thickness of the wall and tied to the long bars by wire. Then cement concrete made in the proportion of 1 : 2 : 4 of cement and sand and stone metal below ¾ inch size, should be laid about one inch thick in the mould previously

made and this frame work of iron should be placed on its top and concrete should be filled in gradually from one end taking care to thrust it in all corners and edges and drive out air, by means of a mason's trowel After about 12 hours the top should be covered with a moist gunny cloth and kept moist for about a week

R. C. C. lintels can either be pre-cast or cast into moulds placed on top of openings (cast in situ), supported from below. Pre-cast lintels are more convenient for openings of normal width say 2½ to 4 feet. One or two moulds can be prepared and lintels cast into them slowly just from the time of starting masonry above plinth at the rate of one per day. After allowing the lintel to remain in moulds for 24 hours the top should be marked with tar to show the correct way of placing it. It should then be removed and kept covered under a moist cloth for two days more and afterwards it should be kept immersed in water for 4 to 5 days or more till required for laying in position.

If lintels are cast in situ, a box consisting of planks about 1″ thick at bottom and longitudinal sides, should be supported in some manner from below and the lintel cast into it as described above. In this case the masonry on the top of the lintels has to be stopped for about a week till they have sufficiently set.

Long lintels, if pre-cast on ground present a considerable difficulty as they have to be lifted up and placed on the top of the opening. In this case casting them in situ is more convenient.

Warning.—A special note of warning must be sounded here in the case of lintels precast on ground, viz., that before they are removed from the mould, a clear mark should be made in oil paint or tar to distinguish the top. In the absence of this precaution they are likely to be used in an up side down

position and they are then sure to crack since the steel rods designed for taking up tension at the bottom go to the top in the reverse position and the concrete which is weak in tension has to bear all the tensile stress.

If the span of openings exceeds four feet it is desirable to use four 3/8 inch iron rods instead of three, the ends of two of them should be bent up at 45 degrees at ¼ distance from both the sides; further two more straight rods of the same length should be placed at about 4 inches above the bottom rods and all these should be tied by wire to keep them at the proper distances apart by U-shaped rings instead of straight pieces as described in the case of shorter lintels shown in figs. 61 to 63.

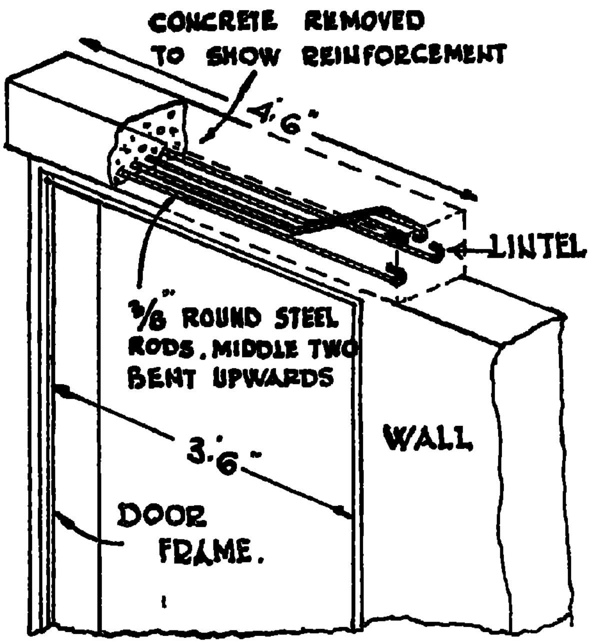


Fig 64 R.C C Lintel Isometric view

Though 4 inch thickness of R.C.C. lintels is normally sufficiently strong for lintels over spans up to four feet, they are usually made of the same height as that of the masonry course. Thus if it is a brick wall the lintels are made of the thickness of two brick courses plus a joint between them. If it is coursed rubble masonry of courses six or eight inches thick, the lintels will also be six or eight inches thick. This may be far stronger than required but it is still adopted because it saves much time and labour ultimately.

Sometimes reinforced brick lintels are also used. The writer has tried them and found them to be quite satisfactory. They are still cheaper and more convenient to make. They are better cast in situ. Only a bottom support is required, there is no necessity of side supports. First lay about one inch of cement concrete on the bottom planks, then lay specially selected well-burnt, hard bricks kept immersed in water for 3 or 4 hours before, flat, lengthwise on the two sides, leaving 1¼" gaps between their ends for joints, then lay the iron frame work previously assembled on the concrete and lay the interior bricks so that the rods of the frame work come in the joints. Fill all the joints with cement concrete; on the top of this lay another layer of bricks as before in cement concrete. In other words, this is just like R. C. C. lintel only bricks are substituted for part of the concrete and that is why they are cheaper.

Arch.

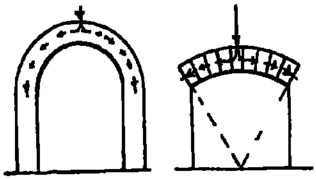
An arch is an assemblage of units of material such as stone, brick etc., placed in a curved outline and wedged in such a way that, when the structure is loaded, the wedges tighten against each other, between the side walls and afford mutual support to bear the load.

An arch essentially consists of two side walls called the "abutments," several arch blocks called "voussoirs" and a central key block, which, when struck, locks other wedge shaped blocks between the side walls called the abutments.

The horizontal line across the opening from which the curvature of the arch starts is called the "springing line", and the vertical distance from the springing line up to the underside of the arch at the centre is called the 'rise' of the arch.

When an arch is loaded, the vertical pressure coming on its crown divides itself into two equal parts at the centre of

the key block, travelling in **opposite** directions through the arch-blocks and ultimately exerts a push called 'thrust' on the abutments as shown in fig Nos. 65 & 66. If the arch is semi-circular i.e., one half of a circle, it has a maximum rise and the thrust coming on the abutments is entirely vertical. If the arch is flat as shown in fig No. 67 i.e., with zero or very small rise, the thrust is mostly horizontal tending to push the abutments outside. Masonry walls can sustain considerable vertical pressure, but they can sustain little horizontal stress. From this point of view the greater the rise of the arch the stronger is the structure, the maximum limit being that of a semicircular arch.



Semi-circular & segmental arches.
Figs. 65 & 66.

Between these extreme limits viz., a semicircular with maximum rise and flat or straight arches with zero or very small rise, there lie arches called "segmental" arches. The outline of the undersurface of such arches is a segment of a circle, less than semicircle. The pressure coming through them on the abutments is partially horizontal and partially vertical.

The centre of a semicircular arch is obviously at the midpoint of the span at the springing level and the radius is equal to half the span. The centre of the segmental arch is lower down on the line perpendicular to the springing line at the midpoint of the span and its radius is much longer.

In the case of a stone arch, it is actually drawn to the real scale on a flat piece of ground with chalk or nail mark, the number and size of archstones and the central keystone is calculated according to the size of stone available after making an allowance for the thickness of joints; the dimensions of one of the archstones and the keystone are transferred to two

pieces of card boards or tin sheets which are cut to those sizes. These are then called "templates". Stones are cut and dressed to the sizes so worked out.

A true brick arch should have wedge-shaped bricks specially moulded and burnt but in practice rectangular bricks of normal size are used and the wedge effect is given by making the joints thin at the lower end and thick at the upper. It is desirable to use specially selected well burnt bricks and rich hydraulic lime mortar or ordinary mortar with some cement mixed with it for arch work in brick. A suitable centering either of wood or bricks laid dry on a wooden support is provided. On the top of this, plaster of stiff mud is applied which is smeared with cowdung and when this is fairly dry and hard, bricks are laid for the arching.

Arches of curvilinear shape are started from both the sides towards the centre leaving a gap midway, into which a 'key' block is struck. Such arches should be built in half brick rings ($4\frac{1}{2}''$ deep) i e, if an arch of 9 inch thickness is required, one whole brick should be laid radially on end at each end near the springing and all the remaining ones should be laid on edges to form two $4\frac{1}{2}$ inch thick rings. This avoids very thick joints and also allows bricks to be interlocked in the direction of the length of the arch i.e., the thickness of the wall and makes the arch stronger.

Especially when bricks are used, flat or straight arches are easy to construct and thus the cheapest. They do not require an elaborate centering beyond just a flat board. Though they are called flat, some rise, say, one to two inches in an opening of 3 to 4 ft. is usually given. This is called the "camber" and is given just to reduce the "drooping" or sagging effect which is very noticeable when the edge is straight.

For a flat arch it is very common to construct an equilateral triangle with the span length at springing line as the

base and the vertex downwards and the apex of the triangle is taken as the centre. The key brick is first laid exactly midway in the centre and side bricks are laid with joints radiating from the centre.

The minimum thickness of a flat arch over a normal door and window openings should be 9 inches. Some cement should be mixed if the mortar is not of hydraulic lime.

Flat arches are sufficiently strong over normal openings not exceeding 4½ ft. But when the load is heavy "relieving" arches are built on the top of flat arches as shown in fig. No. 67. It spans or covers the entire length of the flat arch and thus relieves the latter of its load. A relieving arch is very easy to construct since it has the support or bedding of brick work below, which is already constructed, and thus no centering is necessary. Generally one inch of rise is given for every foot of span.

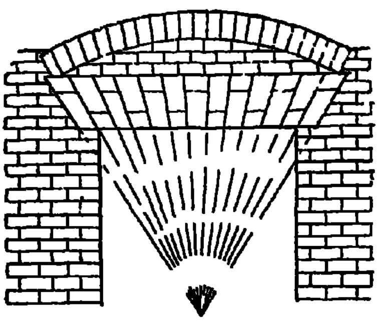


Fig 67.
Flat arch with a relieving arch on top

MISCELLANEOUS MATTERS.

We have to discuss at this stage certain miscellaneous matters which come in the sequence of building operations. The first amongst them is the height of walls or rather the height of the ceiling. There is absolutely no uniformity in practice in India about this. In northern India 12 to 16 ft. height of ceiling is common, which in the Deccan, Gujarat, Karnatik and parts of south India, lies between 8 and 10 ft. This disparity of practice will always remain there, because, it is based on experience. A lofty room is to be preferred to a low one in hot regions, first, partly for the reason that it contains more volume of air; second, to prevent radiation, or rather minimise radiation of heat from the ceiling towards the occupants, particularly of rooms covered with a tiled roof, and also keeping the room cool.

However, from the point of view of economy a lower height of ceiling is better. As regards ventilation, it is not the height of rooms, but the openings provided in the walls, particularly, openings in opposite walls which are of importance. In America, where in some parts the conditions in hot weather season are more or less like those obtaining in India, and also in England and the continent of Europe, the height of ceilings is generally kept 8 ft. With lower height of ceilings the problem of staircase becomes easy, it occupies less floor space and also reduces the effort in climbing, which is a permanent advantage especially in the case of the aged and the sick. Hence, instead of dogmatising it is better to leave this matter to be decided by the individual concerned in the light of the pros and cons discussed above.

The old practice of providing niches and open shelves in walls is not commendable. Recesses in walls for this purpose, howsoever small, should be covered by close fitting shutters of whatever cheap material, for the exclusion of dust or dirt.

However, a niche or a recess close to the floor level, near the main entrance for putting in shoes, slippers, sandals etc., after they are taken off as is the custom in an Indian home, before entering a house, is a necessity. In the absence of this, they are likely to be scattered about. Apart from presenting an unsightly appearance, they cause a great nuisance, sometimes involving danger by allowing dirt and dust full of dangerous bacteria from streets to spread into the house.

Corner shelves, small shelves on wall brackets etc. of plane, simple design for reception of a small statue, vase or ornament may be provided if one is sure that they will be cleaned daily.

Lacquered wooden round pegs, which used to be fixed into the walls at intervals of 5 to 6 ft. at about six feet above floor level, a few years ago, are now out of fashion with the trend of modern architecture. Instead of these a rack of chromium plated or oxidised brass pegs mounted on a wooden board fixed or loosely hung by means of nails in definite unobtrusive places in certain rooms for visitors is preferred. Provision of clothes closets (vide page 146) in bed rooms obviate the necessity of any such exposed fittings for the use of the inmates.

Wall shelves may be required in the store, the bath room and also in the kitchen. For these, pieces of angle or T-iron about two feet long may be fixed at the proper level, projecting about a foot outside the wall to receive a wooden plank 1¼″ thick. If holes are drilled in the angle or T-iron the plank can be fixed by means of screws.

For picture rails, and brackets for small wall shelves for reception of a clock, vase or some such things, blocks of well seasoned wood, of the same shape as that of a brick should be built in brickwalls and left projecting a little beyond the plaster surface. This projection should be sawn before applying the final coat of the plaster so as to leave it flush with the

wall; its position should, however, be easily marked and not mistaken. If this is done later, the wall surface is damaged and presents a shabby appearance.

If the kind and positions of furniture such as chairs, sofas, etc., to be kept in the drawing room is previously determined, wooden boards about one inch thick should be fixed flat against the walls by means of screws at such places, where the back of chairs is likely to strike and damage the plaster. These boards should project only so much that they will be flush with the plastered surface.

In Gujarat, Deccan and South India, portable wooden boards raised about an inch or two above the floor by means of battens nailed or screwed to them called 'Pats' or "Patlas" are used as seats while taking food. These when not in use. are kept leaning against a wall either in the kitchen or in the dining room. They also invariably damage the plastered surface of walls where they rest against them. If wooden planks about 6″ wide are embedded in walls flush with plaster as described above, the damage would be prevented.

Holes in walls may be left for receiving drain pipes, water service pipes, soil pipes from W. Cs. etc. If they are not provided in the first instance, they have to be made afterwards which entail great labour and time and therefore unnecessary cost.

Porcelain pipes about ½ inch diameter should also be inserted across walls for receiving electric wires for lighting and other purposes. This, of course, presupposes forethought.

STAIRCASE.

Proper design and construction of a staircase deserves careful consideration, since most of the accidents due to slipping are likely to take place here The requirements of a good staircase are :—

(1) It should be situated preferably in a lobby, or at such a place as to be easily and independently accessible from any room.

(2) It should be well lighted.

(3) In a residential building its minimum width should be 2′ 6″, though 3 ft. and 3½ ft. are the proper widths for easy and convenient transport of furniture or household goods

(4) The minimum unobstructed head room on the top of any step should be 6′ 6″ although 7′ is better.

(5) There should not be any winding or triangular steps and if they are unavoidable at all for exigency of space, they should be at the bottom rather than midway or at top, to minimise the effect of accidents if any may occur.

(6) The rise of steps should be uniform throughout and should not exceed 9″ in the worst cases. 6 to 7 inches is a convenient rise, though occasionally 7½ to 8 inches is not unusual

(7) The width of the step or the "tread" should not be less than 9 inches. 10″ to 12″ is better.

There are two rules controlling the relation between rise and tread, either of which may be adopted: viz, (*a*) Rise + twice tread= 23 to 24″ and (*b*) Rise × tread=66 inches.

	According to 1st rule.		According to 2nd rule.	
	Rise.	Tread.	Rise.	Tread.
1	5″	13″	5″	13″
2	5½″	12″	5½″	12″
3	6″	11″	6″	11′
4	6½″	10″	6½″	10″
5	7″	9″	7″	9½″
6	7½″	8″	7½″	8¾″

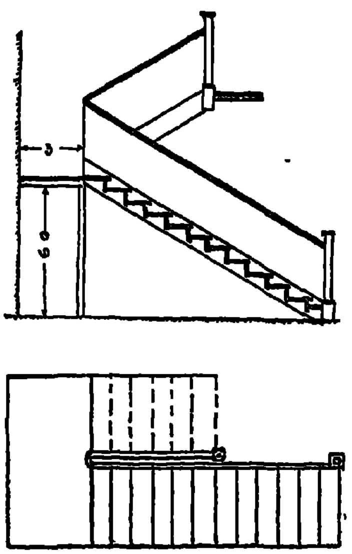
(8) There should be two staircases one on the front and the other on the rear side and if there be only one it should be fire proof.

(9) The stair tread surface should be of non-slippery nature. Waxed or polished wood is worst unless a carpet is used on it. Even polished stone treads are bad.

Examples of staircase computation.

No. 1.

Let the lift from the top of bottom floor to top of upper floor or "storey height" be 10 ft. or 120 inches. If we adopt a rise of 6″, the depth of the tread works out to 11″. $120 \div 6' = 20$ steps. But since the last step is the top of the upper floor while climbing up, or top of the bottom floor, while climbing down, the number of total risers is always one less than this number. Thus in all 19 steps would be required. The horizontal space or the "run" of the staircase would be $19 \times 11 = 209$ inches or 17 ft. 5 inches This much length for one flight is scarcely available in domestic buildings. Besides, climbing 19 steps at a stretch in a straight flight would be tiresome. Hence, it is necessary to divide the staircase into two flights and these two flights must be separated by a "landing" usually of the same width as that of the staircase. Supposing the latter to be 3 ft. we require a total horizontal distance for two flights equal to $17'-5''+3$ or $20'-5''$. Further, whenever a staircase in two flights is provided there is usually a door or a passage below the intermediate landing for which a minimum head-way of 6 ft., and 6 inches for the thickness of the landing must be provided. In order to climb this



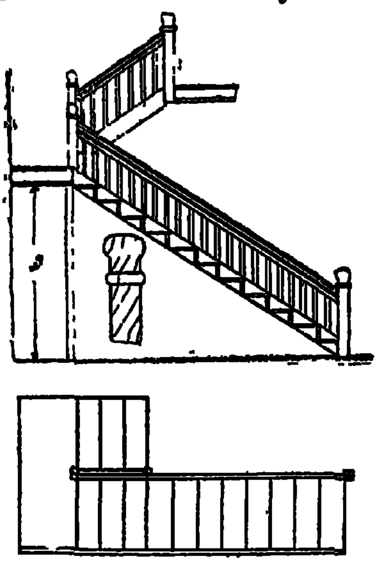
Figs 68, 69

height of 6′—6″ or 78 inches in the first flight we would require $78 \div 6'' = 13$ steps. Our total number of steps is 19. Thus the length of the first flight would be $13 \times 11''$ or 143″ or say 12 ft. then there will be the landing 3 ft. wide and after that the second flight consisting of 6 steps would be $6 \times 11'' = 66''$ or 5′—6″ long as shown in figs. No. 68 and 69.

Example No. 2.

A staircase is to be provided in the front verandah 6 ft. wide of a house. The storey height is 9 ft. If according to (5) in rule No. 2, a 7-inch riser and $9\frac{1}{2}$-inch tread were adopted what would the staircase be like?

Here the storey height being 108 inches and the riser 7″, the total number of steps would be $108 \div 7 = 15\frac{1}{2}$ say 16 i.e., $108 \div 16 = 6\frac{3}{4}''$ riser. The total risers would be 15. The horizontal distance would be $15 \times 9\frac{1}{2} = 142\frac{1}{2}$ inches or 11 ft. $10\frac{1}{2}''$. One flight of this length would in all probability obstruct either a window or a door in an ordinary residential building. Hence, it would be necessary to divide it into two flights. If a six ft. headway is required below the landing also here, as in the last example, and if the thickness of the landing which consists of wood, be 9 inches, we must rise $72 + 9 = 81$ inches in the first flight i.e., $81 \div 6\frac{3}{4} = 12$ steps. Thus the staircase would consist of the first flight of 11 risers, then the landing 3 ft. wide will be the 12th step and after the landing there would be the 2nd flight of 4 steps, the last one being the top of upper floor as shown in figs. No. 70 and 71.



Figs. 70 & 71

A staircase may be either of wood, stone, brick, steel, R. C. C.

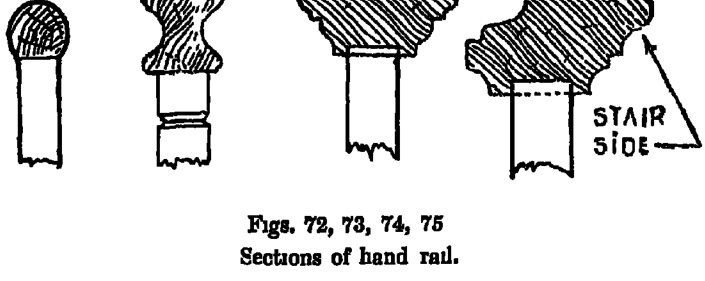
or combination of wood and concrete. If properly designed a staircase forms a central architectural feature to create a pleasant impression on mind just upon entering a house.

(1) Wooden staircase.

At one time wooden staircase was very popular, as it is light and can be given any ornamental treatment. But it is costly, noisy and liable to catch fire. It requires two wide planks called " strings " 12 to 15 inches wide and $1\frac{1}{2}$ to 2 inches thick, on either side, between which the stairs or steps are fixed. For the latter two sets of boards are required one for the tread usually $1\frac{1}{4}''$ thick with a rounded ' nose ' projecting about $\frac{1}{2}$ inch in front of the riser, which is 1 inch thick. Wooden posts $5'' \times 5''$ called " newels " are erected at the foot, head and at changes of direction. The ends of strings are thrust into them. Between the top and bottom newel posts is fixed the railing consisting of balusters fixed on the top of strings and the hand rails on their top. The railing is of a convenient height for rendering assistance in either ascending or descending the staircase.

The two strings are held together at the proper width apart by means of three through iron bolts of 5/8" to 3/4" diameter.

Formerly the balusters were made of various ornamental designs. But as they collected dust and were very difficult

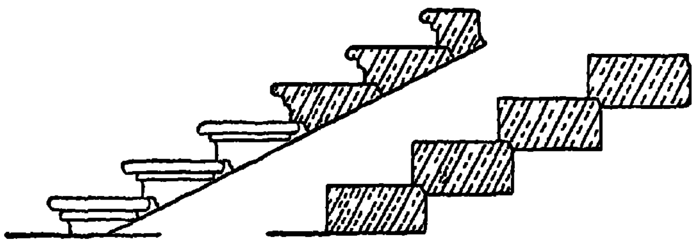


Figs. 72, 73, 74, 75
Sections of hand rail.

to clean, the modern trend is to make the railing of plane smooth surface either of R.C.C. thin wall, finished with smooth plaster, or a hollow wall of plaster boards fixed on both sides of a wood frame. In both the cases a wooden hand rail is fixed on the top. The latter may be of various designs as shown in figures 72 to 75.

(1) Stone staircase.

This is in most cases of a cantilever type, i.e., one end of the steps is fixed into the wall and the other end left hanging.



Figs 76 & 77

The steps are either of rectangular section as shown in figure 77 or of triangular section as in fig. 76. The latter is lighter and allows more space, free from projections below for storing bicycles, perambulators etc., but the cutting and dressing of the steps makes it costly.

(2) Brick in lime staircase.

For this either a solid or arched ramp is first constructed as shown in fig. 78 and regular steps are laid in brick work. For the tread surface and face of risers, wooden boards or flag stones may be used with the front edge of the tread rounded and left projecting about $\frac{1}{2}''$ to $\frac{3}{4}''$.

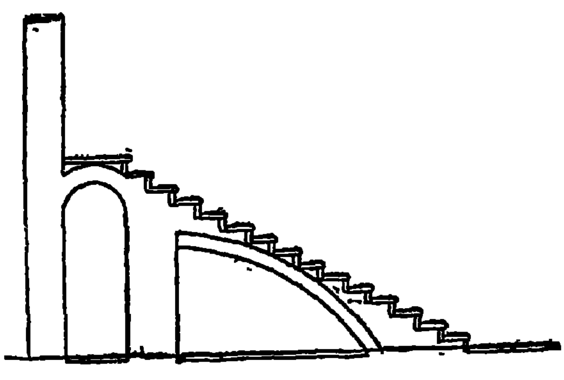


Fig. 78.

(3) Steel and brickwork or concrete stair.

This is a very cheap and at the same time a compact, fire proof staircase. The essential arrangement is to first form a strong and stiff inclined plane of steel, to erect it at the proper incline and to lay regular steps either of brick work or concrete on it. The inclined plane may consist of a frame work either of two angle irons 3″×3″×3/8″ or 4″×1¾″ joists on sides and a T-iron 3″×3″×3″×3/8″ between them spaced according to the width of the staircase with three or four through bolts at different places. When the frame work is erected in position flag stones may be laid on the lower flanges of the frame work and regular steps may be constructed of brick work from the bottom to the top as shown in fig. 79. On the top of these either wooden boards or flag stones may be laid Instead of flag stones it would do if expanded metal is spread and plastered over with cement on both sides and concrete filled in so as to form a slab of any thickness from 1½ inches to 4 inches.

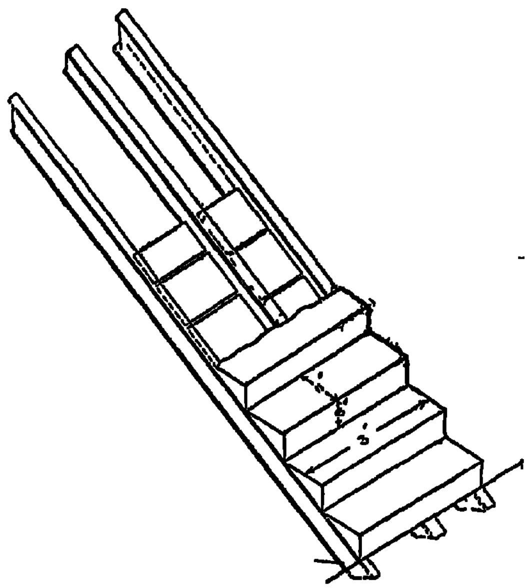


Fig 79
Steel and concrete or brickwork staircase

(4) Combination of wood and lime concrete.

This is virtually a wooden staircase but it is much improved both in respect of soundproofing and fireproofing since the hollow space of the steps is filled with lime concrete.

First notches representing the steps are to be sawn on the top of wooden 'strings' as shown in figure No. 80. Then wooden boards about one inch thick are nailed or screwed on the bottom of the strings, leaving between the latter the proper width of the staircase. Three bolts running through may also be fixed to keep the strings at the proper distance apart. The wooden trough thus formed is erected in position and lime concrete poured into it. As it gets filled up to the notches, boards for risers and treads are fixed on the top of the notches by means of screws and concrete further rammed in. In this way the staircase is formed which looks on the outside as if it is made entirely of wood. The concrete inside makes it both sound proof and reasonably fire proof.

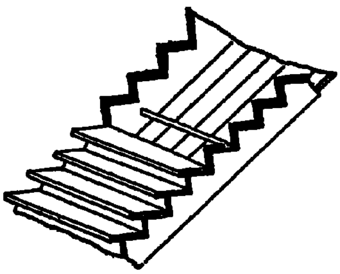
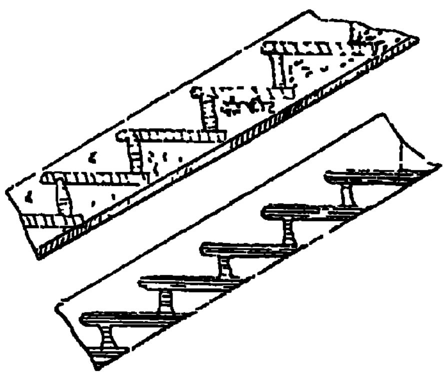


Fig 80

Fig. 81 shows a longitudinal section and fig. 82 side elevation of the staircase.



Figs 81 & 82.

(6) R.C.C. staircase

This is treated in a separate chapter on R.C.C. Construction.

CHIMNEY OR SMOKE OUTLET.

Very often smoke outlets are omitted in Indian Homes, but that is a mistake. In the homes of the middle classes in which kitchens form an integral part of the house, a smoke outlet to carry the smoke and flue gases away before they spread in rooms and darken walls, furniture and clothing, is a necessity. This matter is of particular importance in India, where, very often fire wood is burnt as fuel.

The requirements of fire places in the cold countries of the West are just the opposite of those of the flues of chullas in the tropical countries of the East. The objective in the fire places is to allow heat to spread in rooms by radiation, whereas that in the tropical countries is to prevent heat from radiating in the kitchen, the atmosphere of which is already hot and so the flue gases must be carried off as soon as they are produced.

A flue for smoke outlet works on the principle of convection of heat *i.e.* heated air becomes lighter and tends to rise giving its place at bottom to cold and heavier air from below and thus a "draft" is induced. The flue must, therefore, not only carry off the products of combustion, but also create a powerful upward draft and continually maintain it. Its efficiency depends on the extent to which it functions in this respect.

A flue, in order to be efficient, must satisfy the following requirements :—

(1) It should, as far as possible, be on the inside walls, but when this is not possible or convenient, the wall on the outside of the flue should be at least 9″ thick so as to retard loss of heat.

(2) It should have the inner surface as smooth as possible, because if the surface is rough soot accumulates on it

until the entire passage is choked up and the chimney altogether ceases to work.

(3) A flue with one bend at bottom and another at top is found by experience to give better results. But this may not be always possible for flues of a single kitchen. The bends, however, should be quite easy—not exceeding 60 degrees.

(4) A flue should be carried to not less than the ridge level, if it be somewhere in the middle of the slope of roof or near the eaves. If near the ridge, it should be carried to at least 2 ft. above the ridge.

(5) Flues from two chullas either on the same or different floors should not be united into one. They should be grouped together and carried side by side separately to the top. In this position they assist each other in preventing heat losses. If, however, a flue of a hot water boiler in a bath room, working for only a few hours in the morning be grouped with one of the chulla range in kitchen, the partition between them should be at least 9″ thick, otherwise, when the flue of the boiler is not in operation, the cold air in it will hinder the upward draft of the kitchen flue.

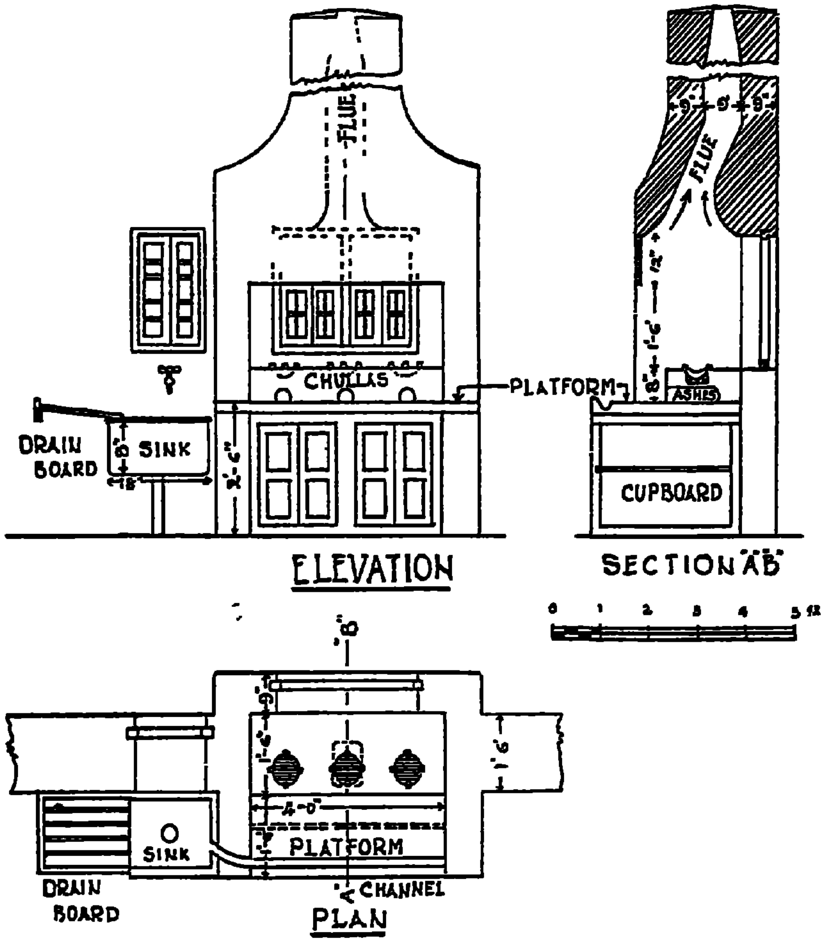
(6) There should be no crack or an open joint anywhere in the masonry of the flue, otherwise, outside colder air might enter the flue and cause a down draft.

(7) The aesthetic importance of a chimney stack should not be ignored. If properly designed it gives a homely appearance to the building. A tall, thin chimney though designed on structurally sound principles would not be pleasing to the eye. It must possess sufficient thickness to satisfy the eye.

For obtaining a smooth surface on the inside, the chimney should be lined with plaster of mortar either of cement

or lime, at every 1′-6″ as the masonry of the chimney is raised, and instead of *neeru,* the final coat should be applied with a mixture of cement, fine sand and cow dung in the proportion of 1 . 3 : 1 respectively, and polished smooth by means of mason's trowel. The top should be covered with a moist heavy cloth.

Figures 83, 84 and 85 show an elevation, section and plan of a range of three chullas suitable for a large middle



Figs 83, 84 & 85.

class family. The rear wall is 18 inches wide, but behind the chullas it is 9″ only. On both sides of the chullas 9-inch brick pillars project on the front side and are carried to a

height of 2 ft. Over them is laid an R.C.C. cantilever lintel in which a hole tapering upwards 9 inches square with rounded corners is made and the same is continued upwards in brick work smoothly plastered on the inside as described above to form a flue.

At a level of 2′ 6″ from the floor an R.C.C. cantilever platform is made on the rear side of which three chullas are installed with their top 10 inches above the top of the platform. The chullas consist of iron grating placed 5 inches below the top for charcoal to rest upon it. A large window on the backside adequately lights the chullas. There is a hollow space formed at 18 inches on the top of the chullas in the shape of a funnel by means of an R.C.C. wall 2 inches thick hanging 1 ft. below the lintel. A channel is provided on the top of the platform to lead the washings to a china sink 18″ x 12″ x 8″ deep fixed on wall brackets. On the left hand side of the sink a drain board consisting of either wood or cement asbestos sheet with corrugations, slightly inclined towards the sink for draining vegetables or utensils, if put there after being washed in the sink. There is a window specially provided for lighting the sink. A number of such chullas have been constructed by the writer and have proved by experience to be the joy and pride of house wives, as, on account of good draft created in the chimney flue, smoke is completely eliminated. Other advantages are :—

(*a*) As cooking is done on a platform either in a standing position or sitting in a chair, the ladies feel far greater ease than in the customary squatting position. Ladies might feel averse in the beginning to this new departure but after a few days experience they

would like it so much that they would never revert to the old practice.

(*b*) Ample extra cupboard space quite at hand is provided in the kitchen below the platform.

(*c*) As the fire is lighted on the top of the platform, there is the least fear of sarees catching fire, of which we so often hear in Indian homes

(*d*) The whole thing can be maintained in a scrupulously clean condition with very little labour.

FLOORING SUPPORTED ON WALLS.

After a discussion of walls, partitions, staircase etc., comes the floor supported on top of walls in the sequential order. However, before we dwell upon it there are a few minor points which cannot be lost sight of. Of course the height of ceiling is one. It is very difficult to prescribe any definite height of ceiling. It depends upon the climatic conditions, local practice and the architectural considerations. As however is already mentioned previously on page 154 if the size of rooms does not necessitate any special increase in ceiling height, a low ceiling is a sure means of economy. From the point of view of ventilation the question of the size, number and position of windows is more important than the loftiness of rooms, 10 to 12 ft. should prove ample for rooms in an ordinary cottage type building. For a room of say 18′ x 24′ size, a height less than 12 ft. would give a stunted appearance. For larger rooms still greater heights would be required from architectural considerations.

Next comes the question of providing a "string course" Just at the floor level of the 1st floor it is customary to provide a course about 6 inches thick, projecting 4 to 6 inches beyond the face of walls all round the building on the outside. It serves several purposes: (1) It is usual to adopt thinner walls for upper floors. Suppose for instance that the outer walls of ground floor are 18 inches thick and it is intended to build 15-inches wall on top of them for the upper floor This can be done by building this either midway on the top of 18″ wall below, leaving a step or an "offset" of 1½″ on either side, or it may be built flush with the outer face leaving an offset of 3 inches on the inner side. The former is better from the point of view of stability, since the centre of gravity of upper walls falls in the centre of lower walls. But the offset of 1½ inches on the outside would not only look ugly, but would

cause rainwater flowing off the face of the upper wall to soak into the lower wall through it A projecting string course here not only obviates this difficulty by allowing the water to flow away from the face of the lower wall, but serves also as an oranamental feature.

The modern trend, however, is to build the upper wall flush with the outer face even at the sacrifice of stability and the convenience mentioned above This is done to bring out an effect of large mass of wall surface in the elevation, which, the string course running horizontally, breaks Incidentally this modern practice increases the sizes of the rooms on the upper floor by a small amount.

The next thing to remember is to treat steel girders suitably if they are to be used as beams before they are fixed and embedded in position. **In no event steel should be allowed to come in contact with lime**; the alkalis in the latter have a deleterious effect on steel. Hence, if they are to be laid in exposed positions they should be painted with two coats of lead paint in linseed oil; a coat or two of cement is not sufficient. If they are to be embedded into concrete or masonry, cement mortar or cement concrete should be used in the portion in contact with them.

Whenever wooden or steel beams spaced more than 4 ft. apart are to rest on top of wall, a bed stone of finely dressed stone or cement concrete 4 to 6 inches thick and of as large a size as convenient is placed between the top of wall and the beam at both ends. These bed plates are called "Templates" and are required for distributing the heavy load borne by the beam on a larger area otherwise the bricks below might be crushed or the stone might settle or slip out.

With these preliminary considerations we shall now turn to the discussion of construction of floors There are different varieties of floors constructed .—

(1) Wooden floors with bridging joists.
(2) Wooden floors and beams.
(3) Steel beams and wooden joists.
(4) Combination of wood and concrete.
(5) Steel joists and jack arches of brick or concrete.
(6) Steel joists and flagstones.
(7) Steel joists and concrete.
(8) Reinforced cement concrete.

The first two varieties are now rapidly falling in abeyance. For, (1) they are liable to catch fire (2) They are expensive (3) On account of short economical lengths of beams, the spans are restricted (4) They shake and vibrate even by ordinary movements of people on the floors. The only advantage of such floors is that they are light.

For these floors wooden wall plates about 3″ x 4″ section are laid in masonry on top of walls and the beams or joists are laid in notches about ½″ deep in them.

For the first kind of floor wooden joists (*burghas*) are laid from wall to wall with their centres 12 inches apart to bridge the whole span. They are hence called bridging joists. They should rest at least 9 inches on the wall. The scantling required is given in the subjoined table :—

Span in ft.	Joists 12″ apart.	Span in ft.	Joist 12″ apart
6′-	2½″ x 4″	12	2½″ x 7½″
8′	2½″ x 5″	14	2½″ x 9″
10′	2½″ x 6″	16	2½″ x 10½″

This kind of floor is uneconomical for spans exceeding 12 ft. For spans about 10 ft. and above the joists need strutting at 5 to 6 ft. apart by pieces of board one inch thick

fitted between the joists at right angles to them and of their full depth to prevent their buckling on sides.

On top of these joists either wooden boards about one inch thick are nailed, on top of it wood shavings are spread in a layer about an inch thick and upon it is spread a layer of 3 inches of stiff mud, the top surface of which leeped with cowdung forms the floor, or flagstones about 1½" thick are laid with longitudinal joints on the top of the joists. These and the cross joints are filled with cement mortar and on the top of the flagstones 3" lime concrete is laid with either tiles or similar thin flagstones set in mortar to form the floor topping.

In certain parts of Northern India and in Sind these wooden joists or burghas are laid 9" inches apart centre to centre and on their top flat clay tiles about 1½ to 2 inches thick are laid with mortar joints. On top of these is laid another layer of similar flat tiles in good mortar breaking joints and on top of this either a mud or concrete floor is made.

(2) In the second variety, wooden beams are laid across from wall to wall with centres 6 to 10 ft. apart and wooden joists are either notched or nailed on to them at right angles with centres 12 inches apart and the remaining floor is made as described above. The sizes of joists will be the same as in the above table. Those of beams are given in the following tables :—

Span ft	Beams 5 ft. apart.	6 ft apart.	7 ft apart	8 ft apart	9 ft apart	10 ft. apart.
8	5"x7"	5½"x7"	5½"x7½"	5½"x8"		
10	5"x8½"	5"x9"	5½"x9½"	5½"x9¾"	5"x10"	6"x10"
12	6"x10"	6¼"x10¼"	6¼"x10½"	6½"x10½"	6½"x11"	6½"x11½"
14	6½"x12"	6½"x12"	6¾"x12¼"	6¾"x12½"	7"x13"	7½"x14"
16	7"x13"	7½"x14"	7½"x14"	8"x14"	8¼"x14½"	9"x15"

(3) Steel beams* and wooden joists.

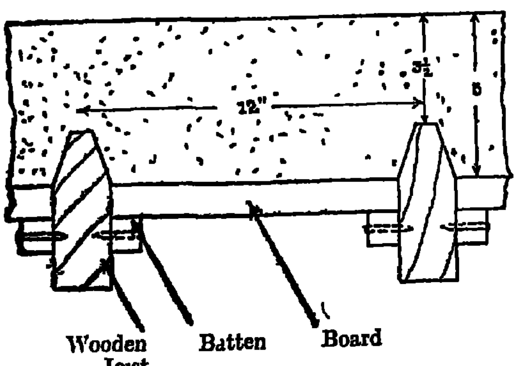
In this variety the wooden beams which are necessarily bulky, limited in length and also expensive are replaced by steel beams. The latter are compact and can span long distances economically. The following table gives the sizes of steel beams for different spans.

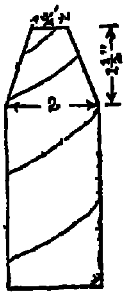
Table of steel girders and wooden joists.

Span in ft.	Bay or the space between girders.	Size of steel girder.	Weight of girder lbs. per ft.	Size of wooden. joists.
		in. x in.		in. x in.
8	6	5 x 3	11	$2\frac{1}{2}$ x 4
	7	6 x 3	12	3 x 4
	8	6 x 3	12	$2\frac{1}{2}$ x 5
10	6	6 x 3	12	$2\frac{1}{2}$ x 4
	7	7 x 4	16	3 x 4
	8	7 x 4	16	$2\frac{1}{2}$ x 5
12	6	7 x 4	16	$2\frac{1}{2}$ x 4
	7	7 x 4	16	3 x 4
	8	7 x 4	16	$2\frac{1}{2}$ x 5

(4) Combination of wood and concrete.

There are two ways of doing it. In (*a*) part of wooden joists is exposed to view from below. It is described below. The wooden joists are cut to a champher at top as shown in fig. 87 and are laid at one foot centre to centre across two walls as bridging joists





Figs. 86 & 87

* The terms steel girders, rolled steel beams and steel joists are loosely used Though they mean the same thing, a joist is a beam of small depth and width The upper and lower flat horizontal projecting parts are called "flanges" and the central vertical plate, the "web" of a joist or girder

in (1) above, or across two beams, as in (2) and (3) above. Then 1 inch x 1 inch battens are screwed on their sides at one inch below the lower edge of the champher and boards one inch thick and of widths equal to the distance apart between two joists are laid on these battens, as shown in the figure 86 to provide a temporary centering. After this, concrete of four parts of broken brick bats, two parts of sand and gravel and two parts of lime mortar, is laid in a layer of 5″ thickness and rammed well. A little cement—say about two handfuls in a basket of lime mortar, may be added and thoroughly mixed if the mortar is not of good quality. The surface should be kept moist for 15 days. After about 10 days the whole centering may be removed.

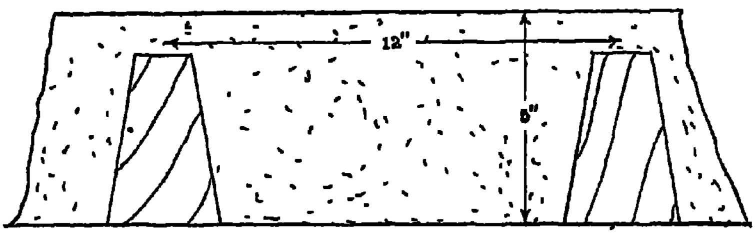


Fig 88

(*b*) In the other sub-variety of this method, wedge shaped joists are sawn out of a scantling 4 inches thick. Each piece should be about 2½″ wide at top and 4″ at bottom and of lengths to suit the bay or the distance between two beams. These are laid in position at 12 inches central distance apart. Temporary centering should be provided and brick bat concrete, as described above made with good lime, should be laid about 5 inches thick and well rammed. vide fig. 88.

Both these forms make excellent semi-fire-proof floors. On account of the wedge shape of joists, the concrete slab formed between them has also a shape of a wedge wider at top, which gives the floor extra strength.

The surfaces of joists should be made as rough as possible to increase the adhesion of concrete. It is desirable to give it a coat or two of hot coal tar before concrete is laid

Since wood is embedded into concrete, it is likely that it may swell by moisture or shrink by heat in the atmosphere and form small hair cracks on the surface of floor. But these are unimportant from the point of view of strength. However, this form of flooring is not suitable for terraced roofs, as leaks might occur through these cracks.

(5) Floor of steel joists and jacks arches.

For this kind of floor, steel girders of the necessary section (*vide* table on page 173) should be first laid either from wall to wall or from beam to beam at not more than 4 ft. distance apart between centres, ($2\frac{1}{2}$ ft. to 3 ft. is better) and arches of brick in lime are built between these with a rise of 1 to $1\frac{1}{2}$ inches per foot of distance apart between steel joists The centering below the arches is rather costly at such a height. However, it can be altogether dispensed with if the following process is adopted :—

Take a piece of wooden board about $1\frac{1}{2}$ inches thick and of a lengthAB equal to the distance between the webs of the joists. Place it on flat ground. Find out the middle point (G) of its length (AB) see the fig. No. 89 and draw a perpendicular through it to AB Extend this perpendicular above AB to C, making GC equal to the rise† of the arch contemplated to be given Then select the point D on the perpendicular by trial, so that the arc of a circle if drawn, will pass through A C and B. Mark this arc on the board and cut it along it Cut about 1/8 inch at both ends A and B Now the centering is ready.

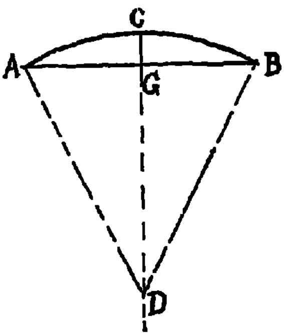


Fig 89

† Usually one inch per ft length of AB

This centering board should be laid about 3 inches from the wall, on edge with the circular part at top on the lower flanges of the joists, between which an arch is to be built. A mason should sit on a plank laid across joists in front and start laying well burnt selected bricks previously kept immersed in water for 2/3 hours. They should be laid on edge. Work should be started from both the joists and closed in the centre of the arch. The end bricks should be cut by a mason's axe to give it a suitable shape, which will fit into the girder and project a little radially and should be laid in cement mortar to avoid steel coming into contact with lime.† The next brick after that at the end should be $4\frac{1}{2}''$ long and should be laid in lime mortar, then a whole brick 9″ long and so on, the first ring of the arch should be built of alternate half and whole bricks. Starting work from both ends of the ring, when the middle of the arch is reached, a key brick should be struck in rather stiff mortar and one or two thin chips either of stone or over burnt brick should be inserted in its joints on both sides and struck lightly with a hammer. After this the arch ring should be supported by one hand, while with the other, one end of the centering board should be pushed forward with light strokes of a hammer, until it is altogether removed clear of the undersurface of the arch.

It should then be placed at about 9 inches from its previous position and the next ring of arch should be laid, this time and onwards, with all whole bricks on edges. The bricks should be interlocked in the gaps left by half bricks in the previous ring filling lime mortar in all the joints except those in contact with the girders in which only cement mortar should be filled. In this way the whole arch should be completed. In the last ring alternate half and full bricks will again be required.

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† Better still, cement concrete may be laid between the flanges of the joists with outer surface sloping in a radial plane, on which end bricks of arch rings could be laid.

It is advisable to mix a little cement in the mortar say about two handfuls to a basket of mortar which would cause the arches to set and harden earlier.

It is likely that in the beginning one or two rings might fall down when the centering board is being removed at the hands of a novice but a little practice will soon engender necessary confidence.

The surface of the arch should be kept covered with moist cloth, grass or wood shavings for 15 days. About a week after the arch is laid the projections of bricks should be cut from below by an axe, the surface watered and plaster laid.

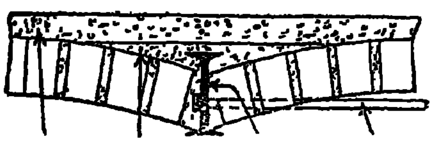


Fig 90

When the arches are properly set in about say 10 days a layer of concrete should be laid on top to a depth of about one inch above the crown of arches. Care should be taken to lay cement concrete on the top of girders to avoid contact of lime with steel as shown in fig No. 90.

Certain safeguards must be taken before the arch work is started, in the absence of which all the arches on the top are likely to collapse by the horizontal thrust of the arches.

These safeguards are:

(6) Before starting the arching the ends of all the joists should be fixed on top of walls in at least 9″ thick masonry or cement concrete up to the top of girders, and only when this is set, arch work should be started.

(2) Three through bolts—two at ends and one in the centre, should be fixed in the two girders at both the ends. In fig. No. 90 one such bolt is shown. This precaution would prevent the end girders from being pushed out by the horizontal thrust due to the arching action which reaches the last girders and there is nothing to resist it.

(6) Steel joists and flagstones.

Joists of steel of suitable section (vide table page 180) should be laid one foot apart centre to centre from wall to wall and flagstones $1\frac{1}{2}''$ thick one foot wide of suitable lengths should be inserted between them from one end to rest on their lower flanges.

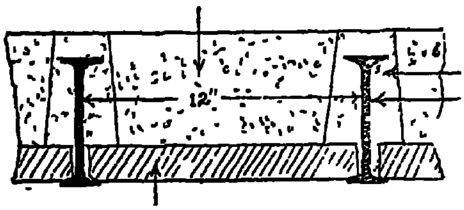


Fig 93

Even if they rest half an inch that is sufficient. After this cement concrete should be laid about one inch on either side and $\frac{1}{2}$ inch on the top of the joists above the flag stones and the remaining portion should be filled with brick-bat concrete flush with the cement concrete. Flag stones about one inch thick should be laid on top of this and the floor finished. This sort of flooring does not require any centering and also does not involve the danger mentioned above in the jack arches. It is cheap in regions where flag stones are cheap.

The above can be made still cheaper by omitting the concrete between the two layers of flag stones and substituting, murum or rock fill, mud etc.

(7) Steel Joists and Concrete.

There are several districts where flag stones are very costly on account of the long distance from which they have to be transported. Here, the following method would prove to be very cheap.

Lay joists of suitable size as per table on page 180 one foot apart. Then erect some sort of centering below them. Even if a few old corrugated iron sheets are available they also will serve the purpose, if their channels or corrugations are filled with mud and wash of cow-dung is given on the top. When

it is dry and sufficiently hard, fill in cement concrete on both sides of the joists as shown in fig. No. 94 to make a sort of wedge and when this is set in a few hours lay brick-bat concrete of rather rich and good quality lime mortar to about ½ inch above the top of joists. If the lime is fat add a little cement. Remove the centering on the 10th day and place it below the next portion. This is a very economical way of making fairly fire-proof and strong floor on the part of a house builder.

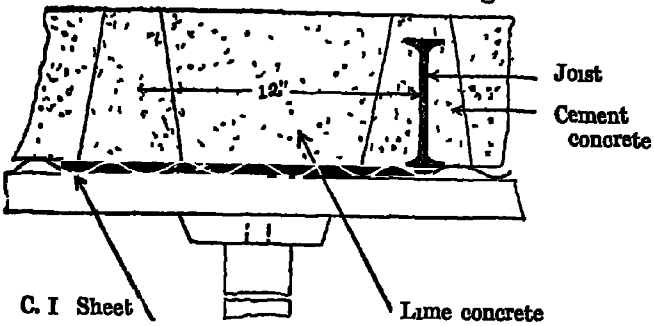


Fig 94

(8) R. C. C. floors are treated in a separate chapter on R. C. C. construction.

The five methods viz. Nos. (3) to (7) described above, require steel joists, and beams. The sizes of those suitable for different spans are given in the following table. How to make use of the table is illustrated by quoting two examples at the end of this chapter.

Section & Weight of joist or girder.	Span in feet	Central distance apart in ft. between joists or girders	
		Medium floor.	Heavy floor.
3"×1½" 4 lbs. per ft.	5	5	4
	6	3	2½
	7	2	1¾
	8	1½	1¼
	9	1¼	1¼
	10	1	...
4"×1¾" 5 lbs. per foot.	5	5¼	4½
	6	3½	3
	7	2½	2¼
	8	2	1½
	9	1½	1¼
	10	1¼	1
	12	1	...

Section & Weight of joist or girder.	Span in feet.	Central distance apart in ft. between joists or girders	
		Medium floor.	Heavy floor.
4¾″ × 1¾″ 6¼ lbs. per foot.	6	5¼	4½
	7	4	3¼
	8	3	2½
	9	2½	2
	10	2	1½
	11	1½	1¼
	12	1¼	1
4″ × 3″ 9½ lbs. per foot.	7	5¼	4½
	8	4	3¾
	9	3¼	3½
	10	2½	2¼
	11	2¼	1¾
	12	1¾	1½
	14	1¼	1
6″ × 3″ 12 lbs. per foot.	8	7½	6¼
	9	5¾	4¾
	10	4¾	4
	11	3¾	3¼
	12	3¼	2½
	13	2¾	2¼
	14	2½	2¾
	15	2	1¾
	16	1¾	1½
	18	1¼	1
7″ × 4″ 16 lbs. per foot.	10	7¾	6½
	11	6½	5½
	12	5½	4½
	13	4½	3¾
	14	3¾	3¼
	15	3½	3
	16	3	2½
	17	2½	2¼
	18	2¼	1¾
	20	2	1½
	22	1½	1

Section & Weight of joist or girder.	Span in feet.	Central distance apart between joists or girders in ft — Medium floor	Central distance apart between joists or girders in ft — Heavy floor
8″×4″ 18 lbs. per foot.	10	9¾	8¼
	12	6¾	5½
	13	5¾	4¾
	14	5	4¼
	15	4½	3¾
	16	3¾	3
	17	3¼	2¾
	18	3	2½
	19	2½	2
	20	2¼	1¾
	22	2	1½
9″×4″ 21 lbs. per foot.	12	9	7½
	13	7¾	6¼
	14	6¼	5¼
	15	5¾	4¾
	16	5¼	4½
	17	4¼	3½
	18	3¾	3¼
	19	3½	3
	20	3¼	2½
	22	2	1½
10″×5″ 30 lbs. per foot.	14	10¾	9
	15	9½	7¾
	16	8	6¾
	17	7	6
	18	6¼	5¼
	19	5¾	4¾
	20	5	4¼
	22	4¼	3½
	24	3½	3
	26	3	2½
12″×5″ 32 lbs. per foot.	15	11¾	9¾
	16	10	8½
	17	9	7½
	18	8	6¾
	19	7	6
	20	6¼	5¼
	22	5¼	4½
	24	4¼	3¾
	26	3¾	3
	28	3¼	2½

How to use the above Tables :—

Remember first that deeper the girder the stiffer it is i.e., it deflects or bends less in the centre. Hence, if a choice is to be made between two girders or joists of almost the same or nearly equal weight the deeper one is stronger for the same span.

The following thumb rule which has been found by experience to give correct results should be remembered :—

Up to 10 ft. span, choose a girder of depth equal to ½ inch per ft. of span. For spans from 10 to 20 ft. it should be ½ inch per ft. of span plus 1 inch. Thus for 14 ft. span it should be 8″ deep (8″ × 4″ girder).

For spans above 20 ft. the depth should be ½ inch per foot plus two inches.

In the above tables methods (3) and (4) of flooring may be taken as medium weight floors and (5) to (8) as heavy weight floors.

Example 1 :—Span 12 ft.; medium weight floor; from above tables the following joists would be suitable :—

(1)	4″ × 1¾″	5	lbs	per ft	One	foot	apart	
(2)	4¾″ × 1¾″	6¼	„	„	1¼	feet	„	
(3)	4″ × 3″	9½	„	„	1¾	„	„	
(4)	6″ × 3″	12	„	„	3¼	„	„	
(5)	7″ × 4″	16	„	„	5½	„	„	

and so on. Under these circumstances those which can be laid closer together are better, because they distribute the load at so many points over the entire wall, whereas, those wider apart put heavier load at only a few points. Hence, (1) and (2) above are more suitable, and amongst them again, the 2nd which is ¾ inch deeper is still better at 1¼ ft. apart.

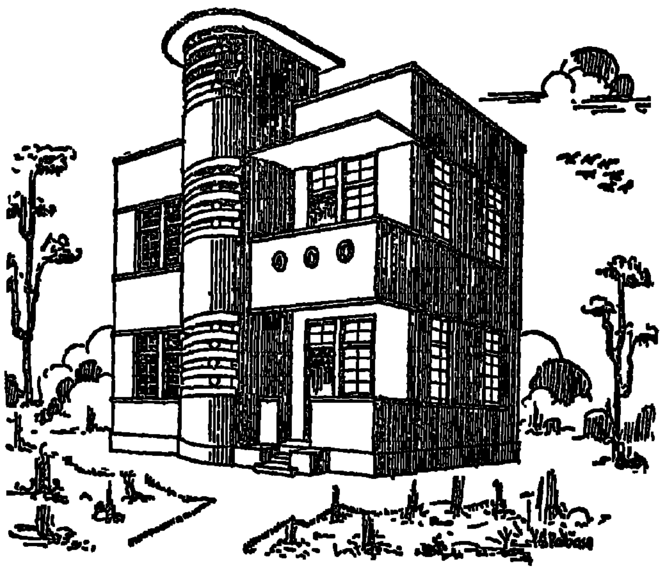
Example 2 :—The span of a drawing hall is 18 ft., the floor is of a heavy type. According to the thumb rule above $18 \times \frac{1}{2}$ *plus* $1'' = 10''$. Thus a girder of 10″ depth and above

would be suitable. From the above table see against $10'' \times 5''$ 30 lbs. girder. For 18′ span the girders may be at $5\frac{1}{4}$ ft. apart or from the next table a girder of $12'' \times 5''$ 32 lbs. per ft. at $6\frac{1}{2}$ ft. would suit. It is better to choose the latter since being 2″ deeper it is much stiffer and weighs only 2 lbs. more per ft. Now to cover the $6\frac{1}{2}$ ft. (say 7 ft.) distance between these girders, if joists and concrete or flag stone method is to be used $3'' \times 1\frac{1}{2}''$ 4 lbs. joists $1\frac{1}{4}$ ft. apart may be used, or if jack arches are to be constructed $4'' \times 1\frac{3}{4}''$ joists $2\frac{1}{4}$ ft. apart, or, $4\frac{3}{4}'' \times 1\frac{3}{4}''$ joists $3\frac{1}{4}$ apart may be used on top of the $12'' \times 5''$ girders.

Important note :—One joist or girder going continuously over several rooms in a line is at least 25% stronger than separate pieces over each room. The maximum length of a joist or girder is 40 ft. Hence, advantage should be taken of the above fact by using as long joists as possible to span more than one room. Thus, if there are three rooms of 12, 15 and 10 ft. spans in one line and the walls are 15″ thick, it is advisable to use 40 ft. joists from the outer wall of 1st room across the middle room to the outer wall of the 3rd room.

PLASTERING.

After the floor on top of walls is constructed the wall surface is protected from the sun, and therefore, plastering of walls can be started. The purpose of plastering the inner



A Charming Cheap Cottage.

Fig. 95.

surface of walls is two-fold (1) from a sanitary point of view a smooth surface does not allow dust, dirt and vermine to lodge on it (2) from a decorative point of view it looks better and can be further treated with either a paint or colour wash.

The requirements of an ideal plaster are that it should be smooth, non-absorbent, reasonably sound-proof, flame retarding and washable, and impervious to temperature.

Lime plaster is better than cement plaster, firstly, because it is cheaper, and secondly, it takes the colour of distemper better. Again, if a nail is to be driven in a wall plastered with cement it bends and has to be tried at several places, spoiling the wall surface. As far as possible the lime to be used for plaster should be fat (vide foot note on page 113) particularly that made by burning sea-shells in a kiln. Hydraulic lime though strong and hard, contains particles

which sometimes slake and expand after six months or a year and when they do so the whole surface of walls presents a blistered appearance which cannot be easily repaired.

Before applying the plaster, the surface of walls should be carefully examined and any projections more than $\frac{1}{2}$ inch beyond the general surface, whether of stones or bricks, should be knocked off. This is an important matter but very often neglected. For the sake of a few projections only, the plaster on the entire surface of the wall must be sufficiently thick to cover them. This not only increases the quantity of the material, but thicker plaster is more likely to fall off.

The layer of plaster simply hangs on the wall surface and so unless it finds a good hold or key into the wall and sticks well to it it would soon beocme loose by its own weight and fall off. To prevent this two precautions are taken viz., that prior to applying the plaster all the joints are raked out to a depth of at least $\frac{3}{4}$ inch by a nail to give the plaster a good hold into the wall and that hemp or hair chopped to pieces about two inches long is mixed into the plastering material. This helps bind the surface together.

After the joints are raked out the surface is watered freely, so that if plaster is applied the wall should not absorb moisture from the material. Lime plaster is applied in three courses.

The first is done with what is called " coarse stuff" ' consisting of coarse sand and lime in the proportion of 3 to 1 in which a little cement is mixed. This is dashed against the wall surface in a layer $\frac{1}{4}$ to $\frac{3}{8}$ inch thick just to roughen the surface to form a key to hold the next course to the wall If the lime is fat the first course should be left exposed to air for two days, and then the 2nd coat called the " floating " coat should be applied. This consists of fat lime and sand in the proportion of 1 : 2 once ground in a mill, left in a heap for two weeks, then mixed with hemp, and ground in a mill

once again, and used. The reason for grinding twice and allowing to remain stale for 2/3 weeks is that if it contains some particles of hydraulic lime (which is the case with most limes) they should be given a full chance to slake at this stage rather than later in plaster when they might spoil the surface of the wall. This second layer should not exceed ½ inch in thickness if the precautions of chipping off projections are previously taken.

Fat lime considerably shrinks as it dries up. Hence, small cracks are bound to appear in the surface. The surface is, therefore, beaten and very closely indented by the edge of a wooden mallet in course of two days after the 2nd coat is applied. This process both drives the lime well into the joints and counteracts the tendency to crack and also makes the layer more compact. The surface should be occasionally watered and left exposed to air for 3/4 days, after which the final coat of "*neeru*" and fine sand in the proportion of 1 : 2 should be applied 1/16 to 1/8 inch thick and polished hard with mason's towel. *Neeru* is made by the following process: Freshly burnt lime of pure chalk or sea-shells is mixed with water to form a thin paste like milk. It is then sieved into a pit about 1′—6″ deep under ground, through khaddar and kept covered, within about 24 hours all the extra moisture is absorbed by the pit and butter like creamy lime is left into it. This is *neeru.*

In some places the surface is polished with powdered talc or soap-stone. Some people mix a little powder of mica in the final coat, as the particles shine in strong light.

Cement Plaster.—There are certain places where cement plaster is preferred to lime plaster e.g., bath-rooms and other rooms in which the walls are exposed to water, W.Cs., inspection chambers of drainage lines, drains and outside surface of buildings etc. Sometimes the inside walls of a house are also

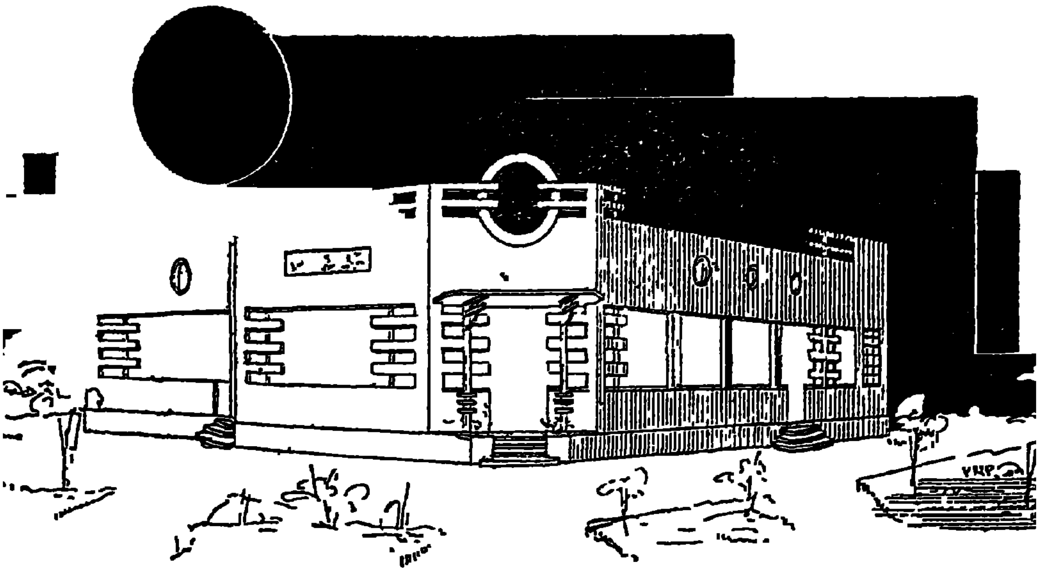
plastered with cement. In the latter case it is advisable to use *neeru* for the final coat on the top of cement plaster, and also mix a little fat lime powder in the plastering material to reduce porosity.

Cement plaster is made in two courses. The first, i e, the rough coat of lime plaster is omitted. The surface is prepared, just like that for lime plaster by raking out joints and watering, then the first coat of sand and cement (4 or 5 : 1) is laid about ½ to ¾ inch thick. Beating the surface with tappers is not required. The surface should be frequently watered and the final coat of cement and fine sand (1 : 2) should be applied 1/16 inch thick and polished. This should be frequently watered for a week. If watertightness is required, as for instance, in water cisterns, the first course should have more cement (say 1 : 3 or 3½), the second coat should be about ¼ inch thick and after the latter is applied and polished 2 or 3 washings should be alternately given by a brush, of water in which bar-soap has been dissolved and solution of alum.

The modern trend is to make the junctions between walls, or walls and floors, or walls and ceilings, rounded. This is called "coving". If a sharp right angle is left, dust and vermin settle there and cannot be swept away easily by a broom. Hence, extra material is filled in here and the surface is rounded afterwards by rubbing a round beer bottle at the junction. Where three planes meet, e.g., at the junction of two walls and floor, or two walls and ceiling, triangular tiles are laid.

Plaster Boards.—Plaster whether of lime or cement, though very carefully made is not very reliable in tropical climates, where the difference in temperature is considerable. For, on account of excessive expansion and contraction small hair cracks are formed on the surface and decorative schemes are ruined. To meet this difficulty plaster boards are now used for the lining of walls on the inside. A variety of these

boards are now on the market such as Masonite, Asbestos cement sheets, Celotex, Plywoods, and so on. Some of these are sold in large sheets $8' \times 16'$. Some of the plywoods have on one side excellent oak or Mohogani finish and a metal sheet on the other. Those with the metal sheet are free from the defect of warping. While the brick wall is being built, wooden pieces are built in, in the face work. To these the plaster boards are nailed or screwed. Putty or wax may be filled in the joints which are very few in number and thus it is hidden under the paint, distemper or varnish.



A Beautiful Modern Bungalow

Fig 96

PAVING OR FLOORING

The requirements of a good paving are that it should be (1) Durable and easily laid, (2) Easily cleaned, (3) Easily repaired, (4) Non-slippery, (5) Noiseless and dustfree, (6) Economical in the first cost and in maintenance, (7) Resilient and (8) Pleasing in appearance, so that there should not be any necessity of covering the floor with heavy carpets which harbour dust and dangerous bacteria.

Foundation of paving is of prime importance. When pavements crack, subside or form patches or holes in the surface they become a serious nuisance and cannot be easily set right. In most cases such defects are due to insufficient foundations.

The best way of providing good and reliable foundation is to prepare a bed of carefully hand-packed stone rubble or hard broken brick at least 9 in. thick and to spread on its top, a layer of 3 in. of murum, gravel or broken brick bat. The surface of this should be freely watered, well rammed and on top of this, a layer of 4 inches to 6 inches of concrete should be laid.

For flooring the following materials are used:—(1) Murum or mud, (2) Brick, (3) Concrete (Indian Patent stone), (4) Flagstone, (5) Polished flagstones, and tiles, (6) Cement tiles, (7) Asphalt, (8) Terrazzo and (9) China mosaic. These are described below in their serial order.

(1) **Murum or mud flooring.**—In rural districts of India murum (disintegrated rock) or mud floors are very often made with scrupulous care and also maintained in excellent condition. Such floors are cheap, easily made and repaired and wear sufficiently long. They further maintain equable temperature both in the winter and summer and are thus very satisfactory for Indian conditions, particularly in the homes

of those who cannot afford the luxuries of costlier types. The only drawbacks are that in order to maintain the surface in good condition an occasional wash of cowdung is given which is objectionable from the sanitary point of view and that it is to a certain extent absorbent. But in these respects also it can be considerably improved if the following process is adopted.

The subgrade should be made of hand-packed rubble or broken hard brick about 9 inches thick, wetted and well rammed. Above this should be spread a 6-inch layer of murum with coarser pieces at bottom and finer at top. On the top of this, a layer of powdery or flaky variety of murum about one inch thick should be spread. Water should be freely sprinkled on it and the surface should be rammed well. After this, copious water should be sprinkled until the floor is fully saturated with water and a thin film of $\frac{1}{4}$ inch of water is formed on the top. The surface should now be trampled under the feet of workmen and levelled until the cream of murum rises to the top. It should then be left to itself for 12 hours and then rammed by means of wooden flat rasp provided with a handle, both in the morning and evening for three days. After this, the surface should be smeared with thick paste of cowdung and the floor rammed for two days in the morning. If it be summer time, it will by now be sufficiently dry to receive the final thin coat of a mixture of 4 parts of cowdung and one of cement applied evenly and wiped clean immediately by hand. The floor made in this way is very smooth, hard and fairly impervious to water.

Once in a week or two, according to the traffic on the floor. the surface should be given a thin wash of cowdung and cement and wiped clean immediately to maintain the surface in a good condition. If a thicker coat is applied, it would soon cake and peel off.

In places where murum or laterite is not available, floor of earth could be made equally well. The difference between a murum floor and mud floor lies in the quantity of water. Whereas water is very freely used in the preparation of murum floor, it should be very sparingly done in earth floor. If the earth as it comes fresh from a pit be moist there is no need of adding any water to it at all. A layer of about 9 inches of soil below the ground surface should be thrown out and the earth below it should be used for making floor. If the surface of the ground from which the earth is obtained shows cracks, the earth should be mixed with sand. The exact quantity will depend upon the clayey or sticky nature of the earth. A layer of 9 inches of loose moist earth should be evenly spread and reduced to about 6 inches thickness by ramming. The final treatment with cowdung and cement is the same as in the case of murum floor.

(2) **Brick-flooring.**—This kind of flooring is very suitable for stores, godowns etc., where heavy articles are put. Sometimes it is done even in residential buildings, but as brick is very absorbent it is not recommended. The subgrade should be made with a 9-inch layer of rubble and 4" to 6" of concrete on its top. Over this are laid bricks of the very best quality throughly well burnt, with sharp corners, either flat or on edge, the sides being rubbed if necessary to give fine joints about 1/16 inch thick. Care should be taken to see that the masons cover the side of the brick last laid with mortar before placing the next brick against it. In no event should the joints be filled by pouring cement or mortar grout from the top. Covering the top with mortar should not be allowed as it is likely to be used to conceal bad workmanship. The bricks may be laid with rows of parallel joints either at right angles to walls or in herringbone pattern.

(3) **Concrete floors (Indian Patent stone).**—If proper attention to details be given this makes an excellent floor.

It is even cheaper than ordinary flagstone paving and still possesses most of the advantages of costlier types. However, if it is not carefully made it gives endless trouble and can never be satisfactorily repaired by patch work. The necessary surface slope in the proper direction to facilitate washing of the floor when finished should be given in the layer of the concrete on subgrade. For inside floors about ½ inch in 10 ft. is sufficient.

The subgrade is made as usual of rubble stone or broken brick packing* and 4″ to 6″ concrete either of lime or cement on its top as already described above. If it is lime concrete it should be watered and rammed for two days and on the third day the wearing coat of cement concrete, as described below, should be applied. If it be cement concrete, the wearing coat should be laid within 45 minutes after the cement concrete is placed and before it is appreciably hardened.

The mixture should consist of two parts by volume of clean, crushed stone, ½ inch size, one part of dry, coarse sand and one part of fresh cement. The materials should preferably be taken on the basis of cement bag as a unit. In that case one bag of cement or 1¼ c.ft., one bag of sand of 2½ c.ft., and two bags of ¾ inch broken stone 5 c.ft. should be taken and mixed twice in a dry state. To this should be added 4½ to 5 gallons (never more than 5 gallons) of water per bag of cement and should be mixed, if by hand, three times. If the mixture is stiff and unworkable more water should *not* be added, but it should be mixed once more. If it is still stiff and not workable the proportion of crushed stone should be slightly reduced and that of sand correspondingly increased.

The top of the subgrade should be thoroughly wetted, but no pools of water should be allowed to stand. Just a little dry cement should be sprinkled for a short distance and this

* This is not necessary for the topping of floors supported on walls

should be swept with a broom and immediately a layer about one inch thick of the mixture should be evenly spread. As this is being done by one mason in the next distance, the portion completed by him should go through the process of screeding, floating, rolling and trowelling by different people immediately one after another. On account of less quantity of water, the surface will be somewhat rough in the beginning and therefore all the above processes should follow in rapid succession in order to bring out a smooth surface. Screeding consists of moving a straight edge with a forward and backward sawing motion under pressure applied by hands, so as also to compact it at the same time when it is being levelled. Floating consists of rubbing the surface with a flat wooden batten in order to fill up the hollows and level the small humps, which might still have been left after screeding. This should be followed by rolling with a small stone or iron hand roller. This operation is very useful in both compacting the layer and smoothening the surface. The portions near the base of columns and walls which cannot properly be reached by a roller should be tamped by a hand rasp or a flat rectangular rammer.

Rolling should be followed by trowelling which is the most important operation for bringing out a proper finish. If the surface is very wet, some time should be allowed to elapse before trowelling is started, otherwise, it would bring out cream of cement to the surface, which will soon shrink and form hair cracks. Too much trowelling should be avoided for the same reason. No dry cement or a mixture of cement and sand should be sprinkled on the surface.

After this the surface should be covered with one inch of wet sand or earth and kept continually wet for 10 days, by sprinkling water frequently. **Do not use wet cement bags to cover the surface; they will stain it.** It should be washed after this and used, or, if smoother polish is required it should be ground either by hand or machine.

In short, for best results avoid (*a*) too much water, (*b*) too fine sand in the mixture. It should be rough and coarse. (*c*) too much trowelling, especially when the surface is wet and (*d*) improper and insufficient curing (covering under moist material).

If a coloured surface is desired, the one inch coat should be divided into two layers of say 5/8″ and 3/8″ each. The mixture for the upper layer of 3/8″ thickness should have the same proportion of materials, but the crushed stone should be slightly finer and the proper quantity of colour pigment should be mixed in it very thoroughly. The shade should be deep enough as it dries to a much lighter tint. If joints are to be marked, a cotton twine should be stretched across the floor either straight or diagonally and hammered lightly as soon as trowelling is done.

(4) **Flagstone paving.**—The slabs should be first dressed for straight edges and right angled corners. Then on a firm unsinkable base of rubble and 4″ of concrete on it (if on the ground floor) or for topping of floor supported on walls, first lay two slabs, on a bedding of mortar about ¾″ to 1″ thick, in two diagonally opposite corners of the room giving the proper grade for washing the floor subsequently. Stretch a string from the top of one slab to that of the other and lay all the intermediate slabs so that their top would just touch the string. Each slab should be firmly bedded on lime and not at a few points only. It should be then struck lightly with a wooden mallet. If one side or a corner is at a lower level the slab should be lifted up and stiff mortar and not pieces of stones should be laid below. If the precaution given on page 135 in respect of raising door sill by a couple of inches is taken, there would be no difficulty in opening and closing the door. Very thin joints should not be insisted on. They should be ½ inch thick.

When all the slabs have been laid the mortar from the joints should be raked out and cement and fine sand (1 3) made into a thick paste with water should be thrust and the joints wiped out. Channelled joints at top are not good as they harbour dust.

(5) Polished flagstones or cement and other tile flooring.

The subgrade should be hard and unsinkable. The necessary fall or slope should be given in the surface of the subgrade. If the flooring is to consist of polished slab stones they should be very carefully dressed. In ordinary flagstone paving, described above, only the edges have to be dressed in straight lines and they are to be made at right angles to each other. But in polished flagstone floornig, all the four sides must be dressed to the full thickness of the slabs ; they are sometimes further rubbed with a steel file. Tiles are either square or hexagonal with sides true and square, still, the latter are filed to remove small projections. On the subgrade a thin coat of mortar of cement and very fine sand in equal proportions is evenly spread and the polished slabs or tiles are truely and evenly set in a thin paste of cement applied on sides. The joints are very thin—as thin as paper. The extra cement which oozes out through joints to the surface is wiped off with saw dust before it hardens. If tiles of different colours are to be laid in patterns, the work must be very carefully done. Water should be occasionally sprinkled over the surface. After 2/3 days the joints are first rubbed with a corborundum stone, so that slight extra projections or edges rising above the surface should be levelled. The whole surface is then polished, first, with a softer variety of corborundum stone and then with a pumice stone and finally the surface is washed with a week solution of soft soap in warm water.

(6) Asphalt floor.

Asphalt on account of its black colour and bad smell particularly in the initial stage, has been regarded suitable

only for outdoor paving and road surfacing. However, with various improvements in its manufacture and use, and notably with the introduction of colour, it is becoming increasingly popular for flooring of inner rooms also. It is invaluable as a hardwearing and watertight material on top of terraced roofs.

The sources from which asphalt is obtained are: (*a*) Natural bituminous rock found in Sicily, Switzerland and France (*b*) Lake asphalt as in Trinidad in the West Indies and (*c*) Artificial asphalt prepared by mixing bitumen and clean sand called mastic asphalt. Asphalt from the first source is the best. But the last is easy to manupulate.

Physically it is hardwearing, non-slipping, quiet, jointless, dustless and impervious to water. Its "plastic" nature makes it very suitable on top of terraced roofs since it conforms to slight movements due to expansion and contraction from difference in temperature.

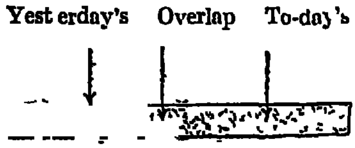
Preparation of mastic asphalt.—The solid asphalt sold in drums is broken to pieces and put into an iron pot which is heated from below. It should be stirred well as it melts. When it is thoroughly fused clean coarse grit, or crushed hard stone in the proportion of 2 parts of sand to one of asphalt is slowly mixed in it while it is being continually stirred until light brown smoke is given out and the mixture freely drops from the stirring rod. The pot should then be lifted off the fire and the compost used as quickly as possible.

Laying the compost.—In ordinary situations one layer of ½ inch to 1 inch should be sufficient. But where infiltration of moisture under pressure is expected e.g. in basement floors, or water cisterns, it is advisable to spread the mastic in two thicknesses breaking joint. Coloured asphalt is always used in two layers, the lower one being of plain asphalt and

the upper of coloured asphalt which is costlier. The compost or mastic, hot from the cauldron should be spread on a previously prepared, hard, unsinkable base of concrete by means of mason's trowel like plaster, in a layer of even thickness and screeded and trowelled while yet hot as shown in fig. 97. Before the compost becomes hard, a small quantity of

Fig. 97.
Laying Asphalt Compost

Fig. 98



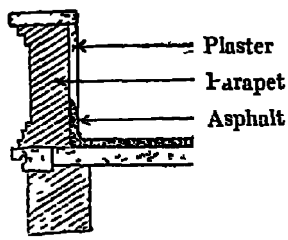


Fig 99

very fine sand should be sifted over the surface and well rubbed into it with a trowel The day's work should not be stopped with a vertical joint, but an overlap of an inch or two should be made as shown in fig No. 98 between the previous work and fresh work. Similarly corners and edges at ends should not be finished with a vertical joint, but they should be rounded by carrying the layer 2 or 3 inches vertically against the wall flush with the plaster as shown in fig No. 99.

(7) Mosaic tile floor.

Solid unsinkable base is prepared, to the surface of which, the necessary fall in the proper direction is given On top of this, lime mortar is laid about $\frac{1}{2}$ to $\frac{3}{4}$ inch thick just in a small portion, which could be finished with tile laying in 3 or 4 hours, to prevent its drying and hardening before the tile pieces are set. On this a thin layer of cement about

1/10 inch thick is sifted and the pieces of broken tiles (either china glazed or of cement) are arranged of such designs in different colours as may suit to form a pattern and in borders.

The breaking of tiles in the proper way is very important. The individual piece should be broken to a shape of a wedge with the glazed or polished side on the broad face. A piece with smaller glazed face and larger under face must be rejected. When the pieces are arranged in a small portion in the necessary pattern, dry cement is sprinkled on the top and either a light roller is slowly passed on it or, a long, flat piece of wood is placed on the surface and lightly hammered on the top, so that pieces are firmly set in the mortar below, without even slightly disturbing the pattern. This must be done carefully for an hour or so until the pieces are compacted to form a level, neat surface. After this the extra cement is wiped off with saw-dust and the surface kept moist by occasionally sprinkling water on it. After about three weeks the surface should be rubbed with a pumice stone and washed with a weak solution of muriatic acid. Slight rubbing with a rag moistened with oil will make the surface lustrous. If broken cement tiles are used polishing with a corborundum stone is advisable.

As it contains innumerable joints, mosaic tile flooring is not good from the sanitary point of view. It is however admirably suitable for terraced roof, since, on account of the number of joints it is not affected by expansion and contraction.

(8) Terrazzo flooring.

This is a special type of cement concrete flooring which has recently come into great popularity on account of its great decorative effect.

The top of the unsinkable base slab should be at least $1\frac{1}{2}$ inches below the level of the proposed finished floor. On

the top of the base a layer of fine sand about ¼ inch thick should be spread to act as a cushioning and this should be covered with tar paper obtainable in market. On top of this should be spread the first layer of a mixture of one part of portland cement to three parts of coarse sand and not less than six gallons of water per bag of cement. This layer should be about one inch thick. While this is being laid, brass dividing strips 1½ inches wide and at least 20 gauge should be placed on edge to conform to the pattern previously designed. When this mixture has sufficiently hardened, the terrazzo mixture consisting of one part of coloured cement

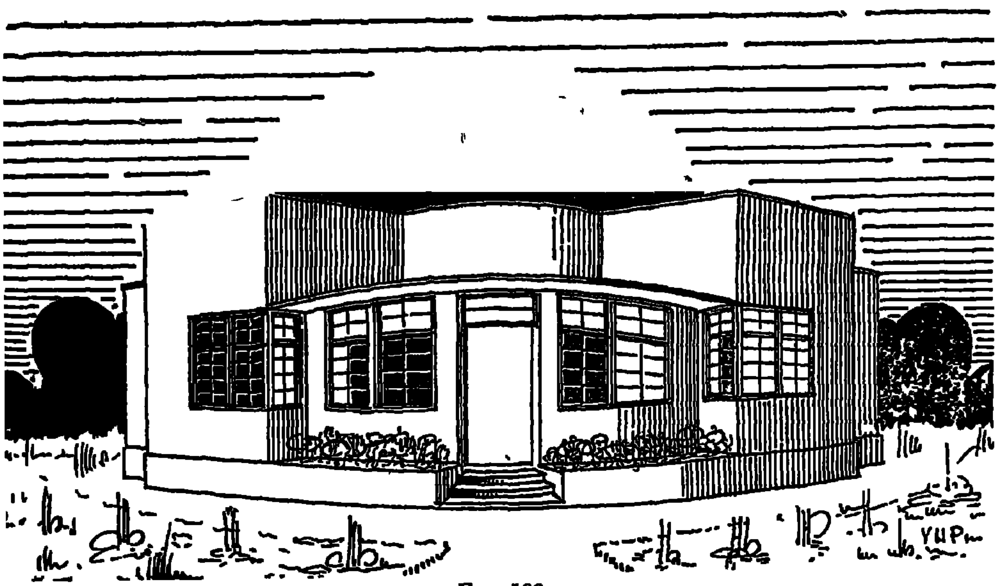


Fig 100.
A Modern Cosy Cottage

to three parts of marble or grantite chips and not more than 4¼ gallons of water per bag of coloured cement should be laid just up to the top of the brass strips and rolled both lengthwise and crosswise. In the course of the rolling operation additional chips should be spread on top as required, until 85 per cent of the finished surface shows stone chips. After rolling, the surface should be floated and trowelled immediately. If different colours are to be used in the pattern, mixtures should be made with cements of different colours

and placed in the patterns defined by the brass strips. The terrazzo mixture should rather be stiff, if it is not workable the proportions of aggregate and coloured cement should be varied to obtain the proper consistency, but in no case more water should be added. The surface should then be kept covered under one inch layer of wet sand for 7 to 10 days.

After the terrazzo concrete has hardened enough, during the above period to prevent dislodgment of aggregate particles, it should be ground with a grinding machine fitted with corborundum grinding surface and while this is being done the surface should be kept wet. Any holes caused by either air bubbles or dislodgment of particles of aggregate should be filled with a thin grout of the coloured cement paste and the surface should be kept moist for seven days. After this period the surface should be lightly ground once more to remove the extra film of grout on the surface and to give a fine polish. This should be washed with warm water and soft soap and wiped dry.

The cushioning layer of $\frac{1}{4}''$ of fine sand and the tar paper prevent any small movements in the subgrade from affecting the terrazzo top.

CEMENT CONCRETE : PLAIN AND REINFORCED.

Compared with lime, cement is very costly. Further, unlike lime concrete, which is mostly used in foundations, cement concrete, particularly when reinforced with steel, can be used in any part of a building, subjected to considerable stresses. Cement concrete must, therefore, be prepared very carefully. Concrete scientifically prepared with careful attention to details may be, for the same cost, 50 per cent. stronger than that prepared haphazardly.

The materials required for concrete are :—(*a*) Cement, (*b*) fine aggregate or sand, (*c*) coarse aggregate and (*d*) water.

(*a*) **Cement** :—The cement should be obtained from approved manufacturers, who sell it under a certificate of guarantee that it complies with the British Engineering Standard Association specifications. It should be obtained in sealed bags, as far as possible fresh, and should be stocked in quantities just sufficient to ensure continuity of work. It should be stored in a dry place on a floor raised at least nine inches above the ground, protected against rain or other source of moisture.

In a concrete mix, the cement should always be used by weight, either by actual weighing or by using 112 lbs bags as equivalent to $1\frac{1}{4}$ cub. ft., one bag forming a unit of each batch. It should never be taken by volume since cement being a very finely ground product, the measure may not be uniformly filled every time. If it is loosely filled, one cub. ft. of its contents might weigh only 75 lbs. whereas normally it must weigh 90 lbs. On the other hand, if it be packed by throwing the weight of the bag on the measure while filling it, one cub. ft. of the measure might accommodate even 100 lbs or more.

(*b*) **Fine aggregate** :—This may consist of sand, crushed stone or other similar material. The best is of course

natural sand, coarse, clean, hard, strong, durable, uncoated and free from dust, mica, shells, and soft flaky particles such as of shale. It shall pass through a 3/16 inch. sieve and shall contain particles of all grades from 3/16 inch to those of smallest size. However, it shall be free from excess of very fine particles and stone dust.

Sands from deep water rivers with sluggish flow or from small streams are likely to contain clay. Hence, for reinforced concrete work of any description it is advisable to get the sand washed before use, unless it is very clean.

It is important to note here that a little moisture, say 5 to 10% in sand tends to increase its volume considerably and that excess of moisture so as to saturate the sand, again reduces the bulk to normal. Thus if one cub ft. of dry sand is measured and mixed with say 5% by weight of water, on refilling the measure it will be found that there would be about 1/3 of a c. ft. of sand left over. Further, if more water is poured into the damp sand in the measure so that a little film of water rises above the top, all the sand will sink down and it would be possible to accommodate all the sand previously left over, into the same measure. This "Bulking" of sand with moisture is very important. If the sand used is damp we use actually 3/4 of the quantity actually required for the mixture and this results in upsetting our calculations of strength and increasing its cost, because more cement is used for less volume of concrete. Hence, either dry sand must be used, which is rather difficult in practice, or, an allowance for the bulking must be made if moist sand is used.

(*c*) **Coarse aggregate** :—This may consist of either broken stone, gravel, sand or softer stuffs such as crushed brick or other artificial aggregates which, however, make poor concrete. The aggregate shall be clean, strong, durable,

uncoated, non-absorbent, well graded and free from dust. It shall not contain flat, elongated or flaky pieces.

The size of the aggregate to be used depends upon the nature of the work. In foundations, or mass concrete of thick walls the size may be as big as $2\frac{1}{2}''$ and below. For reinforced concrete it shall pass through a $\frac{3}{4}$ inch or at the most one inch screen and shall be retained on 3/16 inch screen. It shall contain pieces of all the sizes between these limits Coarse aggregates in India are particularly likely to contain dust either of clay or crushed stone. Hence, it is desirable to screen them before use.

(*d*) Water shall be clean, free from oil, acid, alkali and vegetable matter. The water fit for drinking is always good for concrete.

The characteristics of good concrete are.—

(1) That it must possess sufficient strength for the purpose for which it is to be used

(2) That it shall have the minimum voids left in it *i e* it should be as compact or dense as possible

(3) That its cost should be minimum for the strength and compactness required. Thus it is possible to make a stronger and denser concrete by mixing more cement, but it would be very costly.

(4) That it shall present a smooth and hard exposed surface.

In order to attain these results careful attention must be paid to the following, provided the cement is fresh and of good quality and the aggregates clean and well-graded.—

(1) Proper proportion of cement in the concrete.

(2) Proper proportion of coarse aggregate to fine aggregate.

(3) Proper proportion of water.

(4) Proper mixing.

(5) Proper placing of concrete in moulds.

(6) Proper curing.

(1) It is needless to state that more the quantity of cement in the mixture, the stronger will the concrete be, but at the same time it will increase the cost. Often times the proportion of cement is not the criterion. For instance, concrete made with 25 lbs. of cement per cub. ft. may not be stronger than another made with 20 lbs. of cement per cub. ft. and that the strengths of two concretes made with the same quantity of cement may differ considerably if the proportion of water used in one case is in excess of the other.

(2) Proportioning of aggregates must be so made as to reduce the voids to a minimum. In the first place both the coarse and fine aggregates must contain particles of all grades. One part of cement to two parts of fine aggregate and four parts of coarse aggregate is the standard proportion. But for best results it may be necessary to vary this as it depends upon the size, shape and grading of the aggregates and also on the nature of the work. For taking the ingredients in proper proportions it is convenient to prepare a box open at top with handles, to serve as a measure. Thus if the standard proportion of 1 : 2 : 4 is to be adopted and the cement bag is to be taken as the unit, then a wooden box 1′-7″ x 1′-7″ x 1′ high should be used as a unit measure of sand. When sand is filled in it up to the top and made flat by moving a straight edge across it, it would contain 2.5 c. ft. of sand.

Thus :

One bag of cement $1\frac{1}{4}$ c. ft.................... 1 unit
One measure 1′-7″x1′-7″x1′ of sand $2\frac{1}{2}$ c. ft...... 2 units
Two measures 1′-7″x1′-7″x1′ of coarse aggregate
5 c. ft. .... 4 units.

(3) Proper proportion of water is very important from the point of view of strength of concrete. The lower the water cement ratio the greater will be the strength, provided the mixture is workable. If it is 'harsh' or stiff and so is not workable, instead of adding more water, it is desirable to increase the proportion of sand and correspondingly reduce the coarse aggregate. Sometimes mixing it once more may make it workable. The function of water in concrete is three-fold: to produce chemical reaction, to wet the aggregate and to lubricate the mixture so as to make it workable. Any quantity in excess of this dilutes the cement paste, and causes it to separate from the main mass of concrete. Further, it ultimately evaporates after the concrete has set and leaves pores in it which are then filled by air. As a general rule $5\frac{1}{2}$ to 7 gallons of water are required per bag of cement for a 1 : 2 : 4 mix. The exact quantity depends upon a number of factors such as, the season, absorbing capacity of the aggregates, the size of the aggregates, moisture already present in the aggregates and so on. If the aggregate consists mainly of small particles more water would be required than to wet the same weight of bigger particles because the aggregate with greater number of smaller particles presents a larger combined surface area for being wetted and lubricated.

The rule to be observed is to use as little water as possible consistent with making the concrete workable. If for certain situations, a softer consistency (thinner mixture) is required, *e.g.* in ornamental jali work with fine edges and sharp corners (1) use more of fine aggregate, (2) add more water to make the mixture easily flow into the corners and (3) increase the proportion of cement in order to compensate for the loss in strength due to excess of water.

(4) **Proper mixing**:—Thorough mixing is of no less importance. A smooth water-tight platform of sufficient size is first necessary. A make-shift by using 2 or 3 old cor-

rugated iron sheets is not good. A wooden platform is the best. On small jobs a piece of ground should be dressed and levelled and large sized flagstones may be laid on it dry, leaving joints about $\frac{3}{4}$ inch wide which should be filled with cement concrete and when this has set, the platform should be used. After close of the work most of the slabs can be removed in tact and used elsewhere.

In the process of mixing, dry sand and cement are first measured—cement by bags and sand by the measure of 1′-7″x 1′-7″x1′ high if the proportion be of 1 : 2 : 4. These are first mixed together dry, by turning the pile over twice from one end to the other. The pile is then flattened and the coarse aggregate measured by the same box is spread evenly on it and turned over in dry state twice again. The pile is then flattened and measured quantity of water in the proportion previously determined is slowly sprinkled through a rose of a watering can at one end, while the mixture is being drawn bit by bit by a *phaorah* and mixed. It is likely that balls of cement may be formed by contact with water. If the mixture is rubbed flat against the platform by a forward and backward motion of a shovel, the balls will be crushed and cement properly mixed with the aggregate. This final mixing should be done by turning over the pile several times until the mix is even and no streaks of cement or sand are visible. Hand mixing is a laborious and unsatisfactory task unless the coolies are robust and well-trained. If a power mixer is employed each batch can be thoroughly and evenly mixed in 1 to 1½ minutes. At any rate too much care can never be taken in mixing the ingredients properly.

After turning, the mixture should be placed into forms without loss of time.

Forms:—The moulds prepared for placing the concrete to give it the particular shape are called "forms" or shuttering.

These may be either of steel or wood. Steel forms are costly but they last longer. Wooden forms can be used 3 or 4 times. The wood should be such as does not warp, nor absorb water, nor bend too much under load. Teak is good but very costly. Deal wood is cheap and answers all the purposes well. The forms should be stiffened by adequate supports. Before placing the concrete into forms, their inner surface should be sparingly coated with crude oil. Sometimes they are white-washed or washed with cowdung instead. All chinks and crevices should be stopped with mud and every form should be carefully inspected to see that it is true to line, and level and rigid, according to the design. The shavings and chips of wood etc. should be removed. The forms should be

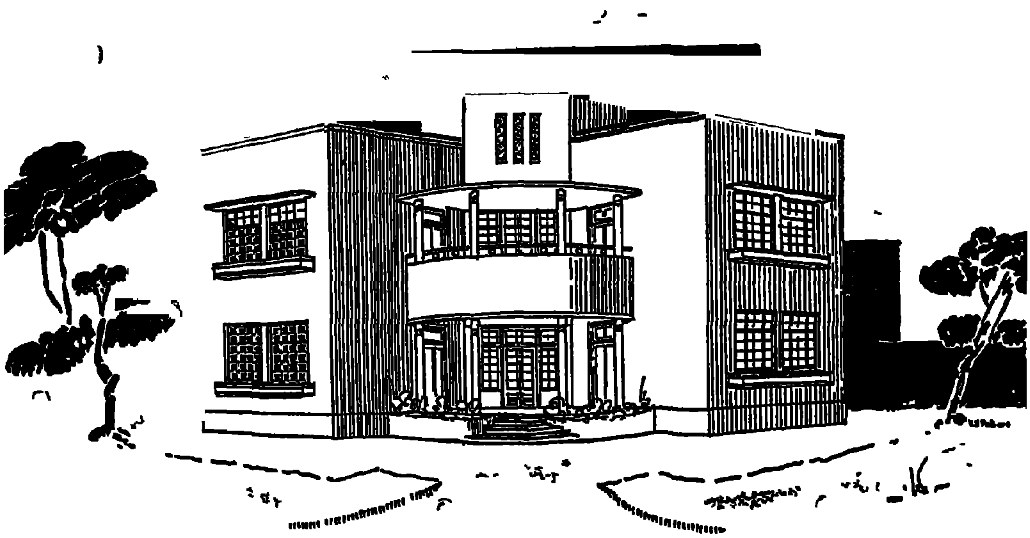


Fig 101
A Magnificent Stately Home

watered freely and all the water should be drained away before concrete is placed into them.

(5) **Placing concrete into forms.**—The concrete may have been well mixed so that the cement paste may be uniformly distributed into its mass. But if it is not filled properly into baskets and placed carefully into forms it is likely

to separate again into aggregate and paste. If English hoes are employed the concrete has to be lifted up for filling it into baskets, and so it is likely to remain in tact, but if Indian phaorahs are employed an unskilled man might draw a little portion from the top consisting of particles of aggregate and slide it into the basket held against his legs in a slanting position instead of thrusting the *phaorah* with force into the heap and lifting both aggregate and paste together to fill baskets.

The basket should not be emptied into the mould from a height. In that case the aggregate which is heavier might fall down earlier, leaving the light and sticky paste behind and thus the ingredients would be separated. Each basket should slowly but sharply be emptied into position from a height of a foot or so and struck lightly on the top of the form so that any paste of cement sticking on the inside should also fall into the mould. If concrete is to be filled in deep forms it should be placed in several thin layers. Cement concrete begins to set so quickly that ramming it is almost impossible. However, some compacting can be done, more particularly, a wooden or steel rod should be used vertically for forcing concrete into corners and driving out air bubbles. Once the concrete is placed it should not be disturbed after 15 or 20 minutes. If the cream of cement or water rises to the top, it may be due either to too wet a concrete, or separation of aggregate from the paste during filling in baskets and placing into mould or, perhaps due to too thick a layer. The cause should be investigated and immediately remedied.

Sometimes electric vibrators are used for shaking the forms as soon as concrete is placed into them. They are very satisfactory in so far as they help in settling the mass and compacting it, driving the air bubbles and bringing to the surface extra water which could then be drained away. They are very valuable particularly in compacting stiff mixes in

difficult and awkward positions, where it is difficult even to place the concrete satisfactorily

(6) **Curing:**—When concrete is mixed well and left to itself undisturbed, the chemical process of gradual hardening takes place in it. This happens only in the presence of moisture and stops as soon as the mass dries out. The rate of hardening is very rapid during the first few days, then it becomes gradually slower and slower. Hence, as soon as the surface is finished it should be covered under a piece of moist cloth to protect it from the action of the sun and drying wind and after a few hours when the surface can bear direct contact with water without being damaged, regular pond of water should be made on it, or a layer of two inches of wet sand or other material spread on it and kept moist by occasionally sprinkling water for at least 10 days. In damp and cloudy weather curing is needed less than in hot, dry and windy weather. If the surface is left exposed during the first few days, not only does the concrete not attain proper strength, but the mass may become porous and surface cracks may also be formed, due to shrinkage.

Water proofing concrete.—There are certain situations in which water proofing is required *e.g.*, basement floors and walls, water cisterns, terraced roofs, etc. The best way of preparing water-tight concrete is to so adjust the proportions that the mass becomes dense and then to attend to all the details mentioned above, *viz.* proper mixing, placing and curing. At the most to reduce the pores still further, a little more cement should be added.

The extraneous materials employed for water proofing may be divided into three different classes.

(1) Those which behave as a **screen or membrane** between the moisture and concrete surface, such as bitumen coated

khaddar or canvas, elastic paints, etc. These are not affected by slight movements in the concrete or cracks in its surface

(2) **Water repellent** materials which are applied after the concrete has hardened They will crack with the concrete and will no more give protection if the concrete cracks. They are: soap and alum (solutions to be alternately applied in 2/3 coats), Paraffin or wax compounds (these do not stand the tropical heat and after some period become inefficient), varnish, boiled linseed oil, resin soaps, etc.

(3) **Pore filling materials:**—These are mixed with the concrete, such as calcium chloride, sodium or potassium silicate, distilled tar, water proof cement. etc.

If it be plain, mass concrete *i.e.* if no steel reinforcement is to be used, a little addition of cream of fat lime (used as *neeru* in the final coat of lime plaster), in the proportion of say, $\frac{1}{4}$ of cement forms a very good pore-filling material and renders the concrete water-tight. It should not, however, be used with steel reinforcement as it would act on the steel.

REINFORCED CEMENT CONCRETE

Introduction:—The design and construction of R. C. C. structures are complicated and highly technical. However, if a layman is acquainted with the general elementary principles, it is possible for him to avoid the common pitfalls, which he is likely to meet even when the design is entrusted to an expert. The writer has met several cases in which pre-cast lintels were correctly prepared, but they were subsequently lifted and placed upside down in permanent position, with the natural result that they were badly cracked—some to a dangerous extent If the Mistry in charge were acquainted with the general principles he could have easily avoided such mistakes. Again, it is possible to standardise certain R. C. C. members required for ordinary small buildings. These

are given here in a tabular form With the assistance of these and the details of them described in as simple a manner as possible, it is possible for a layman to erect a small building This process makes for simplicity rather than for economy, although this may result in the ultimate economy of the work. However, a layman is strongly advised to seek expert advice for works of any magnitude.

As a structural material reinforced concrete has now become very popular. During the last few years it has revolutionised the entire aspect of Engineering. It is a combination of two heterogeneous materials; Cement concrete and steel. Cement concrete is very strong against compression or pressures which tend to compress and ultimately crush it. But it is very weak against tension *i e* a force which tends to stretch it. Steel on the other hand, though very strong both in compression and tension is a very costly material as compared with concrete. Hence, if the two materials were so combined that steel should take up all the tension and concrete all the compression, the combination would both be strong and economical.

Steel and concrete have a natural mutual affinity and further help each other in several ways. Thus steel, if left exposed, soon gets rusted, concrete protects it. Though steel has a smooth surface, the bond or mutual adhesion between steel and concrete is very good—better than that with stone or brick, though both the latter present a rougher surface The extent to which steel and concrete expand or contract due to heat or cold respectively, is the same If it was to vary *i.e.* if the degree of movement between them were different, the bond between them was sure to be destroyed and cracks formed.

The special advantages of R. C. C. as a structural material over either masonry or timber are :—

(1) Wood rots and is destroyed by fire and white ants; concrete is not affected.

(2) As concrete is cast into moulds it is very suitable for ornamental work.

(3) Compared from the point of view of strength it is cheaper than either wood or masonry.

(4) The structure can be made monolithic *i.e.* without joints.

(5) As it can be cast in situ by lifting materials little by little at a time, there is no necessity of hoisting heavy parts, as in the case of stone, timber or steel.

(6) The progress of work can be speeded up to any desired extent.

(7) The repairs are few and far between, if the work initially done is sound.

(8) As it is possible to obtain a smooth or even polished surface at a very little cost, it is clean and admirably suited for sanitary work.

(9) Overhanging galleries, chajjahs and projecting verandah roofs have now become economically possible only on account of this material.

The reinforcement consists of mild steel bars or high tensile welded heavy steel wire mesh. However, bars are in more common use and they are usually round. Bolts, chains, cables and flat pieces are of no use. The surface of bars should be reasonably free from rust. Any extra rust should be removed by a stiff wire brush, no oil should be used as it reduces the bond with the concrete

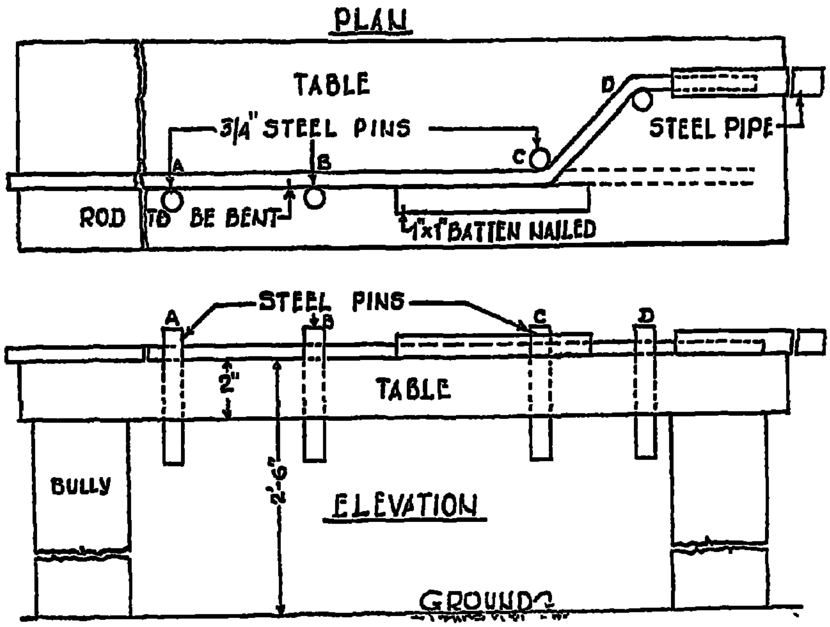
The free ends of bars are always hooked. The minimum size of bars is ¼ inch and the maximum 1¼ inches. ¼ inch bars are available in 12 ft. lengths and others in either 12′. 18′ or 36 ft. The longest bars are more economical. If bars of greater length than 36 ft. are required, or if shorter pieces are to be used for lengthening a bar the best method of jointing is to overlap the ends in a length equal to 45 diameters of the bar and tie them by a wire

All reinforcement is to be wired at a sufficient number of crossings with No. 16 S W. G wire to hold it securely during concreting.

Instead of bars of large diameter laid wider apart, it is advisable to use thinner ones closer apart. For instance, instead of 4 numbers of $\frac{3}{4}''$ bars (weighing 6 lbs. per ft. and their circumference 9.42 inches), if 16 bars of $\frac{3}{8}''$ diam. are used, they would weigh the same *i.e.* 6 lbs. but their circumference would be 18.8″ *i.e.* exactly double. As the adhesive strength of R. C. C. depends upon the bond between steel and concrete the latter though costing the same would be doubly strong.

However, the distance between two reinforcing bars should be not less than $1\frac{1}{2}$ times their diameter.

Bending reinforcement:—The free ends have to be hooked, besides these, a number of bends are to be given to the reinforcing bars. Why they are required and where exactly they should occur, will be described later on. For large works machines for bending bars are used, but for a small job the following simple device may be useful :—



A simple apparatus for bending bars.
Figs 102 & 103.

A plank about 2" thick, 5 or 6 ft. long, and about 8 inches wide, is fixed on two stout wooden *bullies* embedded in earth so as to form a sort of table about 2' 6" high. Four holes are drilled in it and pieces of round bars say 6 inches long and slightly bigger than the diameter of the holes are driven into them as shown at A, B, C and D in the figure, so as to project about $1\frac{1}{2}$ inches above the top. If necessary a batten, 1" x 1" about 6 inches long, should be nailed as shown in the figure, on the top of the table to hold the iron bar to be bent in position. It is possible to bend a bar held flat between these, to any angle desired. If necessry the end of the bar may be inserted into an iron pipe and the latter used for applying greater leverage.

Concrete cover:—Steel requires a good cover of concrete to protect it from rust and some times also from fire. Otherwise the structure may soon deteriorate and fail. The cover for beams and columns should be a minimum of 1" and that for slabs $\frac{3}{4}$". Before placing concrete into forms the reinforcement of beams and slabs should be raised from the bottom and the necessary packing for the thickness of the cover should be given. All the reinforcement should be placed centrally into the forms so as to allow the necessary concrete cover also on sides.

Before we proceed to a discussion of the elementary principles governing the design and construction of the various R. C. C. members such as columns, slabs, beams, etc., it is advisable to give here simple definitions of certain technical terms such as compression, tension, stress, strain, etc. so that the reader may easily follow the explanation given later.

"**Strain**" is the alteration in the shape of a body produced by a force, load or action which calls forth some internal resistance in the body. So long as the force or load is within the ultimate power of resistance of that body, the

strain, or the alteration caused in its shape is temporary and disappears as soon as the force or the load is removed Thus if a certain load were put on a block of rubber, it would be compressed *i.e.* shortened vertically, but it will bulge out on sides and as soon as the load is removed, it will be restored to its original shape The same thing would happen if it were a block of wood, stone or a hard metal subjected to a load. The alteration in shape or distortion in such cases would be too small to be visible to the naked eye. Still, there must be some very minute strain and this must call forth a resistance in the material itself. This means that the material must have been subjected to an internal "*stress.*" Thus a *stress* is caused in a material by the internal resistance offered by the material to an external force acting upon it

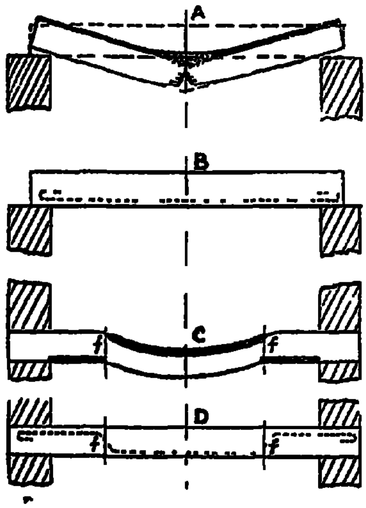
The kinds of stress which we must know in R. C. C work are: (1) Tension (2) Compression and (3) Shearing We shall discuss the first two at this stage

Tensional stress is caused by stretching the material when it is pulled apart by a force and if the material fails ultimately, it will do so by being torn asunder

Compressive stress is directly opposite of tension It is a stress caused when a material is under the action of a load causing it to compress or shorten The material in this case will ultimately fail by crushing

In the construction of an average home one is usually concerned with the following parts of R C C. work (1) Beams, which include lintels, slabs, overhanging chajjahs, galleries, and staircases (2) columns (3) walls and (4) water cisterns.

(1) The simplest case of a beam is that in which the ends are resting on two supports and are free to move when the beam is loaded. This is shown in dotted lines in figure No. 104. When such a beam is subjected to a load it bends so that its bottom is stretched and develops a stress of tension to resist it and the top is shortened and compressed and in that portion the beam develops compressive stress caused by the bending action. If more and more load is put on the beam so that it ultimately fails, it will be seen that it gives way by tearing of fibres at bottom and crushing at top as shown in full lines in figure 104. This indicates that there is tension at bottom and compression at top and since steel is used for taking up all the tension in an R. C. C. structure it is necessary to insert steel bars *at the bottom* of the beam as shown by dotted line in fig. No. 105. leaving below it a sufficient cover of concrete to protect it from rusting.



Figs 104, 105, 106 & 107.

Fig. No. 106 shows another case of a beam in which the ends are fixed firmly inside the wall so that even though the beam bends under a load, the ends are restricted from moving and the beam is unable to bend in one simple curve. It takes the shape shown rather exaggerated in fig. No. 106. A portion of the beam at each end bends with its top surface tending to stretch and the bottom surface tending to contract, while the central portion acts as the beam in fig. 104. Thus there are three curves in the beam. The fixing of the ends, therefore, results in causing tensional stress at top and compressive stress at bottom up to in nearly ¼ portion of the beam from ends and tensional stresses at bottom and compres-

sive at top in the central half. It is, therefore, necessary to insert steel accordingly in places where there is tension. The steel rods are therefore "cranked" up *i.e.*, bent at ¼ length from ends and brought near the top as shown in dotted line in fig. No. 107. The compressive stresses are shown by a thick line at surface in the figures.

If one end of the beam were fixed and the other left simply supported there would be tension at top in the ¼ length of the beam from the fixed end and the remaining ¾ length of the beam will have compression at top and tension at bottom. The steel bars will, therefore, have to be cranked up only at the fixed end and will remain at bottom in the remaining 3/4 length.

There is the third case of a beam in which one end is fixed into a wall and the other end is left free, hanging in the air, as often happens in the case of an overhanging chajjah, or a canopy, or projecting balcony. This case is shown in fig. 108. This is called a '*cantilever*' beam. The reader will easily see that the free end would bend downwards under a load and there would be a stretching tendency or tension at top and contracting tendency or compression at bottom and obviously steel must be provided *at top* as shown in the figure.

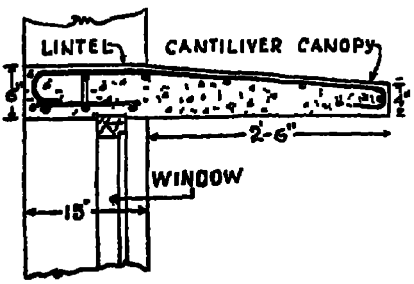
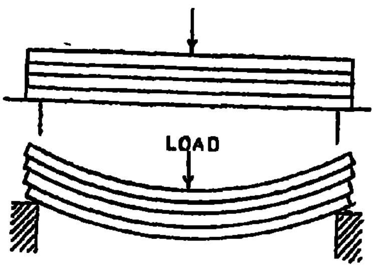


Fig. 108 R. C. C. Lintel with a projecting canopy over a window

So far, we discussed only two kinds of stress, *viz.*, tension and compression. We are concerned with a third kind of stress in R. C. C. work, *viz.*, "*shearing*." It is of the nature of sliding or cutting. The action of a pair of scissors, the two blades of which, slide against each other and cut a paper or cloth, is an example of shearing. When failure occurs

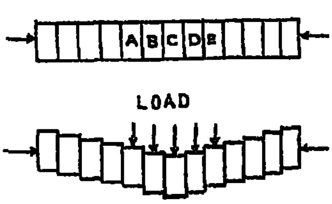
due to shearing the material is separated into two or more portions by the sliding of one section, either horizontally or vertically away from the adjoining section

To obtain a proper idea of shearing force in a beam, the latter may be imagined to be composed of several thin planks, piled one upon the other as shown in fig. 109. When such a beam bends under a load it will be seen that the ends of the plank no longer coincide as before but the planks will slide against each other and assume some such position as shown in fig. 110. This sliding action is due to the *horizontal shearing stress* developed, in an actual beam though such a movement may not be visible, still, the action must be there.



Figs. 109 & 110

The beam may further be imagined to consist of several blocks glued and held fast together by pressure from sides as indicated by arrows in fig. 111. Now if any one or more of these blocks, say the central few, are struck vertically down with a hammer, with a light force, the adjoining blocks also will slide down to a certain extent as in fig. 112. The same action takes place inside a real beam and this is due to the *vertical shear*. The vertical shear is maximum near the supports, because at the ends the supports are pressing the beam in an upward direction from below and half the load on the beam (if it is symmetrically loaded) is pressing here downwards and between these two forces acting in opposite direction there is the vertical sliding or shearing action.



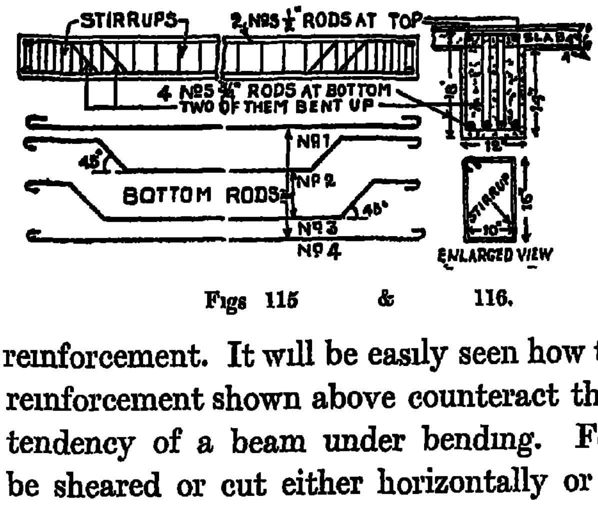
Figs. 111 & 112.

We have said above that concrete is very weak in tension and therefore steel reinforcement is supplied. However in shear concrete is not so weak, still, when the shearing force is considerable, steel is inserted to take up the extra shear. This reinforcement for shearing is supplied in either or both of the following ways.

(1) To bend some of the bars supplied for tension at bottom, upwards in a length of about $\frac{1}{4}$ to $\frac{1}{5}$ span near the supports as shown in fig. 113. The inclined portion of the steel bars resists the shear.

(2) To supply additional rings or stirrups at intervals round the beam. Since the shear is maximum near the ends, the stirrups are closer together at this place than near the centre of a beam. Fig. No. 113. shows a reinforced concrete beam with both the above types of reinforcement. It will be easily seen how the two types of shear reinforcement shown above counteract the sliding or shearing tendency of a beam under bending. For, the beam cannot be sheared or cut either horizontally or vertically unless the steel reinforcement provided is sheared or cut across.

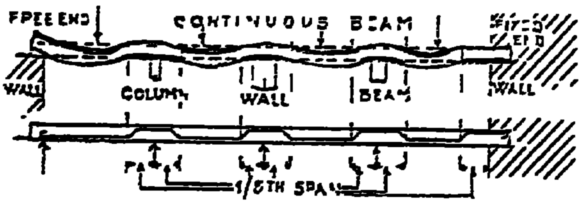
Figs. 113 & 114



Figs 115 & 116.

To revert to our discussion of beams, we have so far considered three types, *viz.* a beam with ends simply resting on two supports, a beam with ends fixed into wall and a beam with one end fixed and the other hanging freely, or a cantilever beam. There is one more type of beams It is a beam which is continuous over several spans, the intermediate supports being either walls, beams or columns. In this case the length of the beam between any two interme-

diate supports can be considered as a beam with fixed ends. In the case of the end span it is generally taken as supported at one end even though that end may be fairly fixed into a wall. The stress in a continuous beam is alternately compression and tension in both top and bottom surfaces owing to the cantilever action on each side of the intermediate support. This tendency is shown in fig. No. 117 which is a representation of a beam continuous over four spans. The thick lines show the portions under compression. Steel must be supplied near the thin lines to resist tension as shown in fig. 118



Figs 117 & 118.

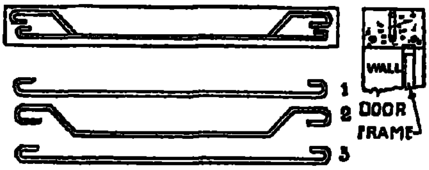
A beam continuous over four spans. The reinforcement is bent at top over each support

From the foregoing discussion the reader may now be able to determine where tension and compression might occur in beams of different types. In order to further assist him in doing this, a tip may be given that he might imagine the beam to be made of rubber. so that it easily bends even under its own weight. He might then visualise the different curves in which it would bend and thus easily determine where exactly tension would occur,* demanding steel reinforcement. As an exercise he might examine all the different types of beams shown in figs. 102 to 114 in the light of the above tip, and check his results. He will remember that each support from below. whether it is a wall, beam or a column, causes tensional stress in the top in the part directly above it and a little on either side and requires reinforcement to be inserted there at the top, whether in the form of bottom rods cranked and brought up in that portion, or separate pieces of bar inserted at the top.

* Tension occurs near the surface of the outer side of a bend and compression near the inner side

We are now in a position to understand the details of different types of beam which we shall now discuss in more detail.

(a) **Lintels**. These are short beams bridging the gap or opening in walls such as for a door, window or cupboard



Figs. 119, 120 & 121

Since usually there is a considerable load of walls on their ends, they might be regarded as beams with fixed ends and thus they have some tension *at top* in about ¼ lengths from ends and considerable tension *at bottom* in the middle half as shown in fig. 106, page 216. The three rods, therefore, must remain at bottom in the middle portion and one of them (usually the central) needs to be cranked up at ¼ distance from either end and brought near the top as shown at 1, 2 & 3 in the fig. 119 to meet the tension at top near the ends. The ends of the remaining two bars may be so hooked that the ends of the shorter legs of the hooks go as far as the faces

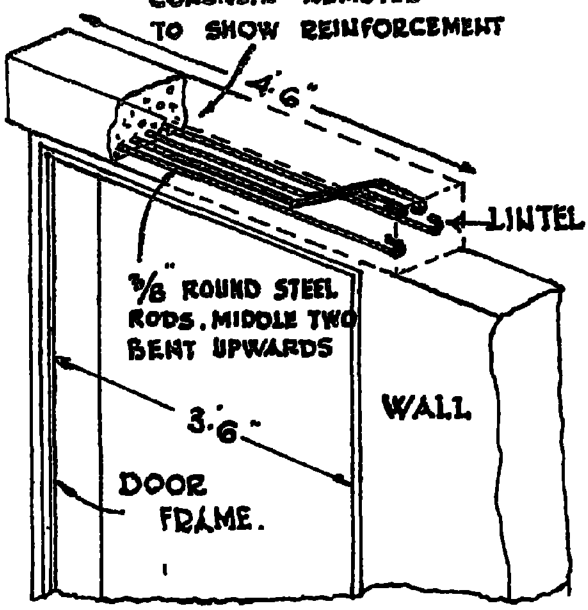


Fig 122

of the openings. In that case they will also help to take up tension near the ends. The shear will be taken partly by the concrete and partly by the diagonal portions of the bent up bar. The bars are tied down to 3 or 4 short pieces of ¼" to ⅜" rods placed across by wire

When the length of the gap exceeds six feet a stronger lintel is required and it is prepared just like a beam with four bars at bottom, two of which are bent

up at $\frac{1}{4}$ distance from the ends and two small bars say $\frac{1}{4}''$ to $\frac{3}{8}''$ are inserted at top just for the convenience of tying stirrups round by wire. See Fig. 122. The stirrups may be of $\frac{1}{4}''$ round rods 12 inches apart.

The subjoined table gives the number and diameter of rods for various spans of lintels for 14 to 18 inches thickness of walls :—

Span in ft	Thickness in inches	Bars at Bottom				Bars at top hooked		Remarks
		Simply hooked		Hooked & bent up				
		No	Diam.	No	Diam.	No	Diam	
$2\frac{1}{2}$	3	2	3/8	1	3/8			
3	3	2	3/8	1	3/8			
$3\frac{1}{2}$	4	2	3/8	1	3/8			
4	5	2	1/2	1	1/2			
$4\frac{1}{2}$	6	2	1/2	1	1/2			
5	6	2	1/2	1	5/8			
6	6	2	1/2	2	1/2	2	3/8	1/4″ rings 12″ apart.
7	6	2	1/2	2	1/2	2	3/8	
8	7	3	1/2	2	1/2	2	3/8	

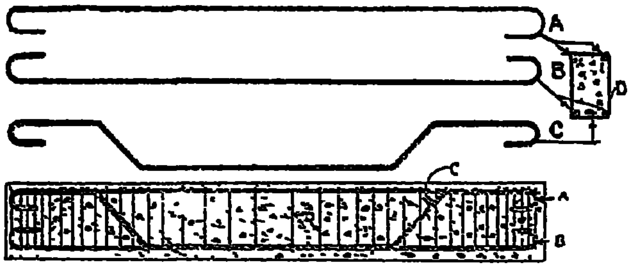
The lintel should rest minimum of 6 inches on walls on either side.

Beams : It has been already discussed that beams may be either (*a*) with both ends simply supported, (*b*) with one end fixed into wall and the other left hanging (cantilever), (*c*) with both ends fixed into walls or (*d*) continuous over two or more spans

From the foregoing discussion especially from the analogy of a rubber rod, the reader will easily determine where tension would occur and where therefore, steel must be provided. Regarding shear, it is sufficient to remember that in every beam nearly half the number of the bottom bars must be bent at $\frac{1}{4}$ to $\frac{1}{5}$ span from the supports and their ends brought parallel to and near the tops and further, rings or stirrups must be

provided for—closer near the supports and wider apart near the centre.

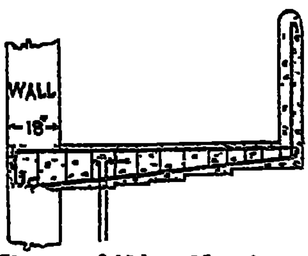
Figures 123 to 125 show the parts A B and C of a typical beam, 124 shows a cross section with a stirrup D and Fig 125 the complete beam It will be seen that there are two straight bars at the top to serve as the corners of the steel frame There are two straight bars for tension at bottom with upward hooks and there is in addition a third middle bar also for tension at bottom which is cranked up at ¼ distance from ends. Besides these there are stirrups closer at ends. tied to the bars by wires



Figs 123 124 & 125

This is a typical beam with essential number of parts. but if the beam is reinforced also for compression to reduce its depth, there may be more number of straight bars at the top and if the beam is heavily loaded more number of bottom rods may also be required. However usually not more than half their number is cranked up to meet shear.

Figure 126 shows a typical case of (b) *i e* cantilever beams with one end fixed and the other left hanging A cantilever beam must be thicker near the support and as it has tension at top the steel bars must be near the top. Figure 126 shows a balcony. Its thickness near the support is 9 inches and that near the end is 6 inches



Stirrups of ½" bars 9" centres
Cantilever for a balcony
Fig 126

The overhanging canopy on top of window shown in fig. 108 page 217 is another instance of a cantilever beam.

(c) A lintel, spanning more than 5 ft. distance with bars both at top and bottom and stirrups, is the case (c) of a beam with both ends fixed.

(d) When a beam is continuous over more than two spans the reinforcement has to be bent in such a way that it comes near the surface in the portions where there is tension. The thin lines in figure 117 (page 220) show the portion where there would be tension. The inclined portions of the bars wherever they are bent diagonally, and the stirrups, take all the shear

Slab

A slab is a beam of smaller depth. A 12" strip of it is designed just as a beam. Thus a slab may also have all the four varieties of beams mentioned above.

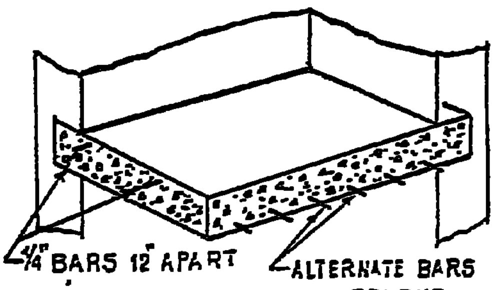


Fig 127
Perspective view of a section of a slab over a single span

The most important point for economy of reinforcement in a slab is to reduce its span. Because the shorter the span, the stronger and more economical is the slab. The reduction of spans is made from the following considerations :—

(1) If the space is oblong with width less than 12 ft., the width is taken as the span. Thus in rooms 8' x 14,' 10'x16' or 12'x18'. 8. 10, and 12 are taken as the spans and main reinforcement is provided in their directions.

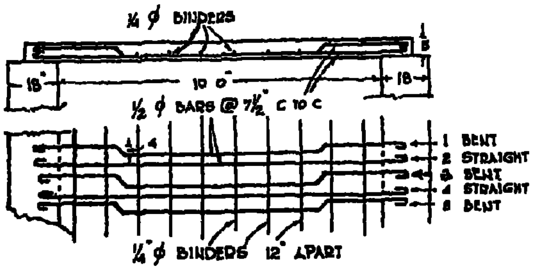
(2) If the width of such oblong space exceeds 12 ft, intermediate beams are provided at not more than 12 ft. apart and the distance between the beams is taken as the span. Thus in a 18' x18' space. one central beam would make two bays of 18'x 9' each : in a 15'x24'

room one beam would make two bays of 15′ x12′ or two beams would make three bays of 15′ x 8′. In these cases 9′, 12′ and 8′ would be the spans and the main reinforcement will be provided in their directions.

But some people do not like these beams. They prefer a flat ceiling. To meet this demand,

(3) Two spans at right angles to each other are imagined, the shorter as the main and the longer as the subsidiary one, and steel is provided in *both* directions. This arrangement makes the slab stronger even with a less depth. But, for this, the spaces to be slabbed should have length and breadth equal or nearly equal. As the length increases the advantage is progressively reduced, until it altogether ceases when the length is equal to twice the width. Thus in rooms 15′x32′, or 16′x36′ introducing one central beam or wall would divide them into two rooms of 15′x16′ and 16′x18′ respectively, which are very nearly square. The reinforcing steel is divided and laid in two directions at right angles to each other. This results in increasing the strength and reducing the cost and presents an absolutely flat ceiling from below.

The following table gives details of the thickness of the slab including ½ inch cover and the size and spacing of steel rods for single spans Alternate bars are cranked up at [illegible] span from ends as shown in figures 128 & 129 and ¼ inch rods are laid across and wired to the main reinforcement at 12″ centres.



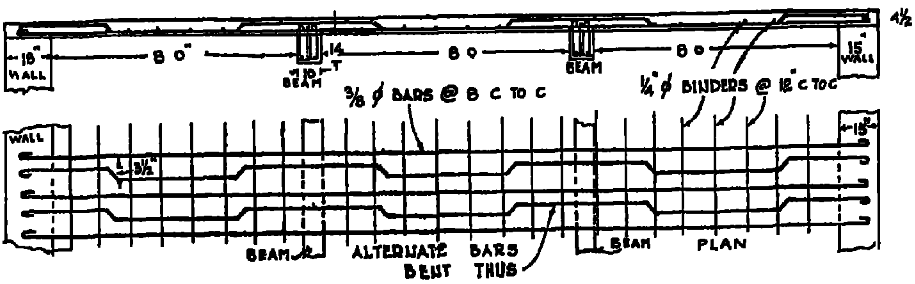
Figs 128 and 129

Slab over a single span showing how alternate bars are bent

Table of R. C. C. Slabs over single spans.

Span in ft	Thickness of Slab in inches	Reinforcement	
		Diameter inches	Spacing inches
5	4	$\frac{1}{4}$	6
6	4	$\left\{\begin{array}{l}\frac{1}{4}\\ \frac{3}{8}\end{array}\right.$	$\left\{\begin{array}{l}4.5\\ 10\end{array}\right.$
7	4	$\frac{3}{8}$	$8\frac{1}{2}$
8	$4\frac{1}{2}$	$\frac{3}{8}$	7
9	$4\frac{1}{2}$	$\left\{\begin{array}{l}\frac{3}{8}\\ \frac{1}{2}\end{array}\right.$	$\left\{\begin{array}{l}4\frac{1}{2}\\ 8\end{array}\right.$
10	5	$\left\{\begin{array}{l}\frac{3}{8}\\ \frac{1}{2}\end{array}\right.$	$\left\{\begin{array}{l}4\frac{1}{2}\\ 7\frac{1}{2}\end{array}\right.$
11	5	$\left\{\begin{array}{l}\frac{3}{8}\\ \frac{1}{2}\end{array}\right.$	$\left\{\begin{array}{l}4\\ 7\end{array}\right.$
12	$5\frac{1}{2}$	$\frac{1}{2}$	6

The following table gives details as above in the case of a continuous slab. Alternate bars are cranked up as shown



Figs. 130 and 131
Showing a slab continuous over three spans and how alternate bars bent

in figures 130 and 131 and $\frac{1}{4}''$ rods are wired on top at 10 to 12 inches centres. It is worth nothing that wherever there is a support from below such as a beam, column or a wall, there must be tension at top of the slab above the support, and reinforcement must be brought near the top as shown in the above figures.

Table of R. C. C. continuous Slabs.

Spans in ft.	Thickness of slab inches	Reinforcement			
		End spans		Middle spans	
		diameter	Spacing	diameter	spacing
5	4	$\frac{1}{4}$	8	$\frac{1}{4}$	9
6	4	$\frac{1}{4}$	5	$\frac{1}{4}$	6
7	4	$\left\{\begin{matrix}\frac{1}{4}\\ \frac{3}{8}\end{matrix}\right.$	$\left\{\begin{matrix}4\\ 10\end{matrix}\right.$	$\frac{1}{4}$	$4\frac{1}{2}$
8	$4\frac{1}{2}$	$\frac{3}{8}$	8	$\frac{3}{8}$	9
9	$4\frac{1}{2}$	$\frac{3}{8}$	6	$\frac{3}{8}$	7
10	5	$\frac{3}{8}$	$5\frac{1}{2}$	$\frac{3}{8}$	6
11	5	$\frac{1}{2}$	10	$\left\{\begin{matrix}\frac{3}{8}\\ \frac{1}{2}\end{matrix}\right.$	$\left\{\begin{matrix}5\\ 9\frac{1}{2}\end{matrix}\right.$
12	$5\frac{1}{2}$	$\frac{1}{2}$	7	$\left\{\begin{matrix}\frac{3}{8}\\ \frac{1}{2}\end{matrix}\right.$	$\left\{\begin{matrix}4\\ 9\end{matrix}\right.$
13	6	$\frac{1}{2}$	6	$\frac{1}{2}$	7
14	6	$\frac{1}{2}$	5	$\frac{1}{2}$	$6\frac{1}{2}$

The following table gives details of a cantilever slab. The bars should be bent as shown in figs. 132 to 135. And every third

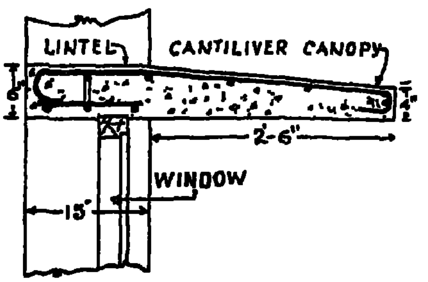
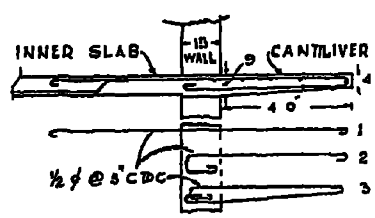


Fig 132
Vertical section & Plan of a cantilever slab showing how reinforcement is bent



Figs 133 & 134
Section of an R C C cantilever canopy combined with a lintel over a window

bar should be bent at the free end and carried near the bottom and anchored fully as shown in figs. 132 and 133. In addition, $\frac{1}{4}$ inch rods should be wired both at top and bottom at 12 inch centres.

Table of details of R. C. C. cantilever floor.

Span in ft.	Thickness of slab in inches		Reinforcement		Remarks.
	At support	At free end	Diam	Spacing inches	
2	5	$2\frac{1}{2}$	$\frac{1}{4}$	4	For chajjah or canopy.
3	5	$2\frac{1}{2}$	$\frac{3}{8}$	4	
4	6	3	$\frac{1}{2}$	5	For balcony or gallery.
5	$7\frac{1}{2}$	4	$\frac{1}{2}$	$4\frac{1}{2}$	
6	9	4	$\frac{5}{8}$	6	For Roof Slab.
7	$9\frac{1}{2}$	4	$\frac{5}{8}$	5	
8	10	$4\frac{1}{2}$	$\frac{5}{8}$	4	

Caution :— The cantilever slab should be anchored into the wall to the full width of the latter and if it be a balcony or a roof slab, the main reinforcement should go at least equal to the projection, behind the wall into the slab, or better still, the bars of the slab behind, should be bent up and extended to form the reinforcement of the cantilever.

For ordinary domestic buildings the balcony should not project more than 4 ft. unless specially designed by an engineer.

While constructing R. C. C. slabs the following points should be noted :—

(1) The minimum cover at the bottom should be $\frac{1}{2}$ inch.

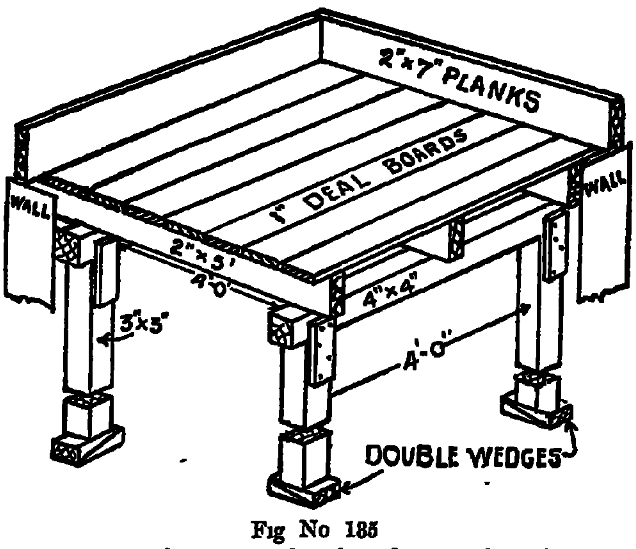


Fig No 185
Form work for a slab Double wedges are placed below vertical supports, to enable the form work being tightened or removed without jerks

(2) Alternate bars should be cranked upwards at $\frac{1}{5}$ span from the supports and brought near the surface.

(3) In addition to the designed rods as per tables above $\frac{1}{4}$ inch rods should be laid at 10 to 12 inches apart across them and tied by wire.

(4) Special care should be taken to see that rods do not bend down under the weight of coolies placing the concrete. This is particularly important in the case of cantilever slabs. Otherwise, the latter may crack

(5) As far as possible the concreting of slabs should be done in one operation without stopping, but, if it is impossible, the joint may be left in the middle of the span and *not on the top of a wall or a beam*

(6) The wall supporting a slab should have a minimum thickness of 9 inches, if of brick in cement mortar, or 14 inches if of brick in lime mortar.

(7) Even a $4\frac{1}{2}$ inch brick partition on top of a slab must be supported either by a wall or a beam.

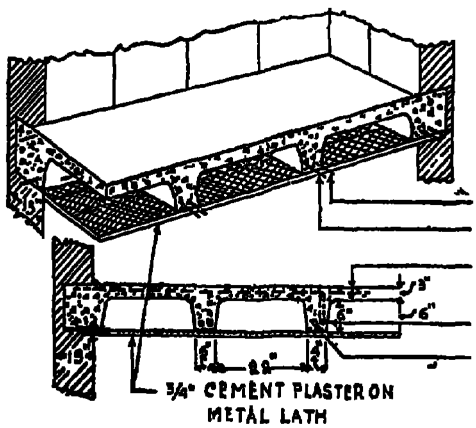
(8) The slab should rest on walls at least 9 inches. Greater bearing is preferable and the slab becomes stronger in that case.

(9) Concrete blocks of at least 18 inches $\times$ 6 inches thick and of the full width of the wall should be provided as a bedding for the ends of beams.

(10) A continuous beam or slab is much stronger and economical. Hence, instead of using separate pieces of steel for each room, the rods should be extended from room to room across the top of walls or beams.

In addition to the varieties of R. C. C. floors mentioned above there is one more called the T-beam or a ribbed floor.

because the beams are in the form 'T'. If an ordinary plain steel sheet is supported at two ends and is loaded in the centre it would bend, but a corrugated sheet of the same weight and thickness would take a much bigger load without bending. The reason is that the corrugations or ribs give it extra stiffness. On the same principle, R.C.C. floor is provided with ribs as shown in fig. Nos. 136 & 137. This kind of floor requires least steel and thus is most economical, particularly for large spans. But the ribs look unsightly from below. Hence, sometimes, a flat ceiling of expanded metal fixed to the bottom of the ribs and plastered over with cement is made. Figure 136 shows perspective view of a section of a T—beam floor, fig 137 its longitudinal section.



Figs. 136 & 137.

Perspective view and longitudinal section of a T-beam floor

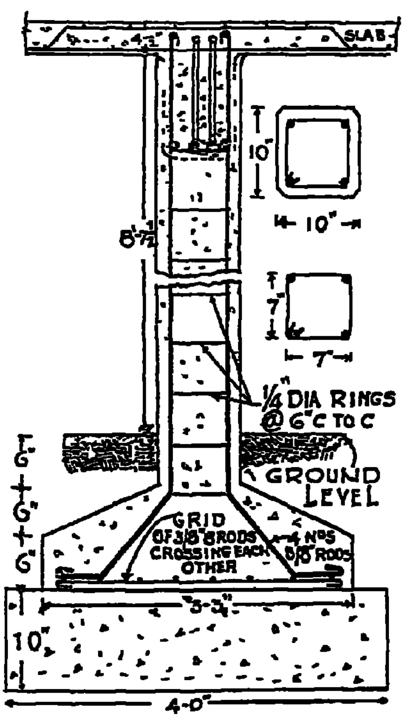
Columns:–As the storeys of ordinary residential buildings are never more than 12 ft. or at the most 14 ft. high, the design of R.C.C. columns even in a building of framed structure (*vide* page 110) is a simple thing.

Foundation: Simple verandah posts need not have separate foundations. It would do if they rest on the plinth masonry, just like wooden posts.

Columns bearing heavy load, such as those on which ends of three or four beams rest, or columns of R.C.C. framed structure need separate foundations. For these a square or oblong pit is excavated according to the shape of the column. The length, breadth and depth of the pit depend upon the load, and the nature of foundations. A layer of

6″ to 12″ of lime concrete is spread at bottom and rammed on its top is placed a box-like shuttering. open, both at bottom and top, and on a three inch layer of cement concrete in it, is placed grid work of steel consisting of steel bars hooked at ends placed across each other and tied by wire at every crossing. The framework for the column, made of vertical bars with rings of smaller bars (usually $\frac{1}{4}''$ round.) wound round them either separately or continuously in a spiral and tied by pieces of wires, is erected in the centre of the grid work and cement concrete is placed into the shuttering.

Such a column complete with footing is shown in fig. 138. The trench for foundations is 4′ x 4′ x $2\frac{1}{2}'$ deep. There is one foot of concrete at bottom, then an offset of $4\frac{1}{2}''$ is left on all sides and cement concrete is laid into the shuttering. The grid is 3′x3′ and consists of 8 $\frac{3}{8}''$ bars at 5 in. centres tied to each other at crossings. The frame work of the column consists of four $\frac{5}{8}$ in. bars, round which rings of $\frac{1}{4}$ in diam. bars are wired at 6 inches centres. The length of the column is 10′ and its overall section including the cover of $1\frac{1}{2}''$ is 10″ x 10″. The core or inner frame work is 7″ x 7″. (fig 140).



Figs 138, 139, 140.
R. C. C Column with footing and a beam with slab on top

The column carries a beam at top. The main or vertical reinforcement of the column is carried to the top of the beam.

A column may also be oblong or circular in section. These

latter requires a minimum of 6 vertical bars. The concrete cover round columns, whether rectangular or circular should be a minimum of one inch.

Verandah posts carrying the load of roof need be 6" x 6" including one inch cover with $\frac{3}{8}$ in. vertical bars, four in number, if the posts be square, and 6, if circular. tied by wires to $\frac{1}{4}$ inch rings at 8 inches centres. For columns carrying the load of one storey, the section should be 8" x 8" with one inch cover and four $\frac{5}{8}$ inch rods inside, surrounded by rings of $\frac{1}{4}$ inch diam. rods at 6 inches centres. For columns carrying heavier loads the section and the number of bars should be increased and the rings tied at 3 to 5 inches.

Figure No. 141 shows columns and a beam above them cast in one piece. On the top of each column extra reinforcement is supplied near the top of the beam to take up the tension (*vide* page 266) and at the junction of the column with the beam, shoulders are widened and extra pieces of

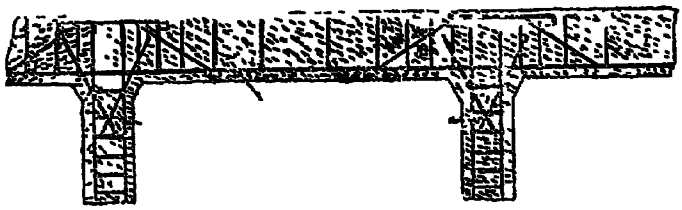


Fig. 141
R. C C Columns with a continuous beam in one unit.

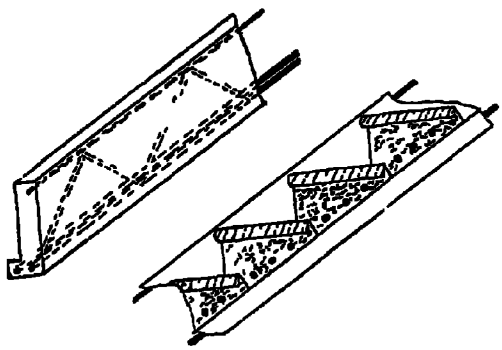
steel are placed diagonally and tied both to the column and beam on both sides of the column. These are required for meeting the excess of shear which occurs at the junction.

The function of rings in a column is important. They prevent the column from bulging out and causing the steel to be separated from the concrete under heavy loads. The diameter of the column should be not less than $\frac{1}{15}$ of the height, with a minimum of six inches.

Staircase.—R. C. C. staircases possess certain advantages over those of wood. They are cheaper, fireproof, easy to keep clean and free from noise. They can also be very easily and quickly made.

The staircase may be either of (a) inclined flights of steps resting at bottom and top or (b) cantilever steps with one end of each step fixed or anchored into a wall and the other left free or hanging.

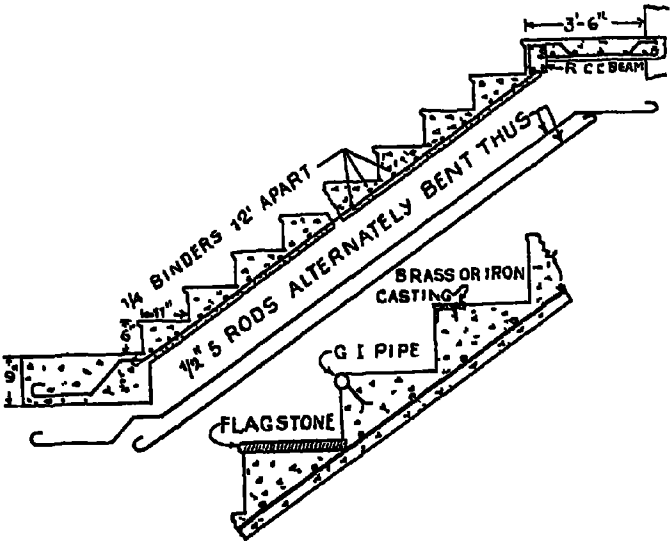
The stair case of the form (a) can be made in two different ways, *viz.* (1) in which both the strings (*vide* page 160) on sides and every step are provided with separate reinforcement and are cast in separate units and are assembled together in position and the joints are filled with cement grouting, *i.e.*, a paste of cement and fine sand (1 : 1). This is not only elaborate and troublesome, requiring a number of wooden forms but takes also a long time to cast. Figure 142 shows a string of the right hand side when climbing the stair case. There are two $\frac{3}{8}''$ bars at bottom and one $\frac{5}{8}''$ diam. at top and these are joined by diagonal bars shown dotted. The thickness is about 3 inches and depth 15 inches. There is a ledge of $1\frac{1}{2}''$ on the left hand side on which the steps rest. Figure 143 shows a cross section of the steps laid in position on the left hand side string. Each step is separately cast into mould and has a notch at bottom which causes it to fit properly on the top edge of the lower step.



Figs 142 & 143
R C C Stair case with strings & steps cast separately & joined

(ii) The second method is very easy and is recommended for adoption to the layman house-builder. It is this:

First calculate the length of the slopes by the method suggested on page 158. If the staircase is 3 ft. wide or less, take five numbers of $\frac{5}{8}$ inch bars of length equal to that calculated, plus about 3 ft. for anchoring into the foundation and/or the landing. Bend them as shown in Fig. 144



Figs 144, 145 & 146

(alternate bars should have the ends to be embedded into foundation and for the landing, cranked up). Keep them parallel to each other at equal distances, leaving 2 inches of space on sides, then tie pieces of $\frac{3}{8}$ inch rods laid across them at 12″ centres by wires at every crossing and erect the frame work in the inclined position on the site of the staircase. After this, a trough-like shuttering should be placed beneath it, 5 to 6 inches deep and of width equal to that of the staircase, plus three inches on one or both sides for the railing. Then place concrete into the trough so as to form a slab with a cover of one inch below the steel frame work. For steps either, boards of the necessary width may be mounted on edge across top of the slab and concrete placed to form steps monolithic with the slab, or, twenty-four hours after laying the slab, start laying brick masonry either in lime or cement mortar (1 : 6) to form regular steps of the necessary depth and thickness. The centering, in the latter case should not be removed before the 10th day.

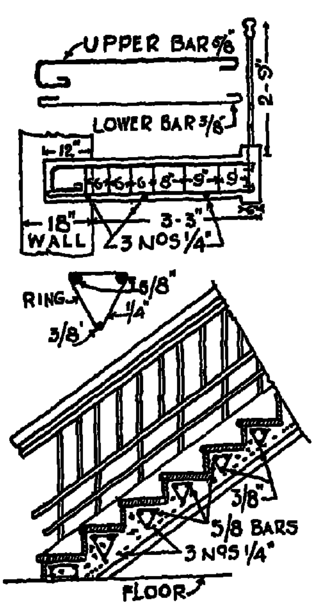
The top of the steps may be covered with marble, flagstones, wooden boards, cement tiles with chequered surface

etc., one inch thick, with a nose projecting not more than ½ inch. Alternatively, concrete topping may also be made of about one to one and a half inch thickness, of ½ inch crushed stone or gravel and cement 3 : 1, laid within an hour of placing of the concrete in steps, or any time if the steps be of brick masonry. For obtaining a non-slippery surface indentations should be formed by laying a piece of expanded metal on the top and striking it lightly over a wooden batten under the hammer, within 4 to 6 hours after laying the top course.

The edges of concrete steps are likely to be knocked or chipped off by anything striking against them and they cannot be properly repaired afterwards. To prevent this either pieces of galvanised pipes ½ in. diam. or iron or brass half round or angular nosing may be fixed while laying the top course, the former by wires tied to the pipes and embedded into the concrete, and the latter, by means of nails or screws into the concrete. Both these and also a flagstone are shown in three different steps in figure No. 146.

Figures 147 to 150 show a typical R. C. C. cantilever staircase. The steps are projecting 3-3″ outside and are anchored one foot into the wall. As a cantilever has to resist tension at top, two ⅝″ bars with bends and hooks as shown in figure 147 are provided at top and one ⅜ in. bar at bottom of each step, to form a triangular frame work of steel, and triangular rings of ¼ inch bars (fig. 149) are tied round at 6 inches centres near the support and 8 to 9 inches further on. The frames of each step are con-

Figs 147, 148, 149, 150



nected together by three rods of $\frac{1}{4}$ inch diam. running lengthwise parallel to the length of the flight.

Figure 150 shows a cross section of a few steps with the railing in elevation. The latter consists of $\frac{5}{8}$ inch. square rods with lower ends hooked, wired to the steel frame and embedded into concrete and the upper end supporting a wooden hand rail.

ROOF

The object of a roof is to give protection from the sun, rain, wind, and snow where it falls. The appearance of a building also depends upon how the roof is made.

Roofs are either flat or pent. The latter is also called pitched or sloping. Flat roof may either be terraced so that it can be used as a sitting place, or a flat mud or concrete roof just for protection from rain.

Let us discuss the pent or sloping roof first. The slope of a roof depends upon (1) the climatic conditions, and (2) the surface material used for roofing. In England and also in a few hill stations of India snow falls in winter and forms a thick layer. The latter cannot slide down unless a minimum of 45° or 1 to 1 slope is allowed. On the other hand there are a number of places where the rainfall is less than 20 inches annually. In such places the sun is very hot and greater protection is required from the heat rather than rain. It must not however, be forgotten that even in such places, though the total annual rainfall is small the individual downpour is not of small intensity and so, if the slope is small, great inconvenience is likely to be caused though for a short time.

It is advisable to have a roof as simple and plain as possible. The less the number of valley gutters in a roof the better it is. As far as possible horizontal gutters on the top of walls should be avoided. This is particularly of importance when the walls are either entirely of mud or of mud mortar. In the latter case it is advisable that the roof should project at least two feet beyond exposed walls to protect their top portion from piercing rain. In ordinary cases $1\frac{1}{2}$ ft projection should be sufficient.

The following are the slopes usually adopted :—

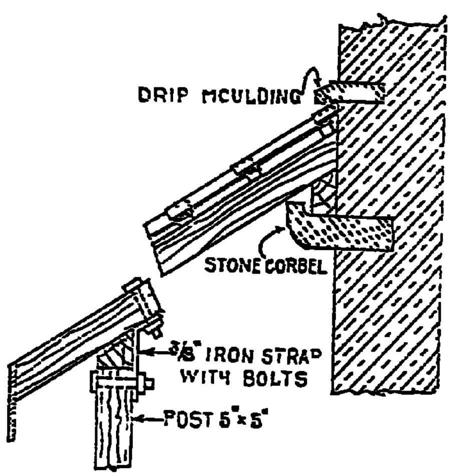
Mangalore pattern tiles .. .. 7" per ft

Pan or other pattern flat tiles	7" per ft.
Half round country tiles .	6" per ft.
Galvanised corrugated iron sheets	2" to 4" per ft.
Trafford sheets (Corrugated asbestos cement sheets) . .	4" to 6" per ft.
Concrete flat terraces according to the proportion of annual rainfall and the waterproofing material used. ...	from 1" in 24 ft. to 1" in 50 ft.

The sloping roof may consist of either (1) Single slope or verandah roof (2) Two-way sloping or gabled roof, or (3) Hipped roof.

Verandah roof :—The higher side of a verandah roof generally rests either on a wall or a beam resting on 'templates' or 'corbels' of stone, R.C.C., or wood, built into a wall as shown in fig. 152.

In case of such roofs rain water striking against the outer surface of the wall is likely to flow down the wall surface at the junction of the roof and the wall, into the verandah. To remedy this a 'drip moulding' of brick is built into the wall just above the roof, projeting about three inches to drop the water from its surface on to the top of the verandah roof as shown in fig. No. 152.



Figs 151 & 152

If the other side of the verandah roof rests on vertical posts, a beam called "postplate" is laid on the top of posts.

On the top of this come the principle rafters, then purlins and on the top of these the common rafters, battens and tiles. All this makes the roof very thick and also expensive Instead of that it is possible to omit the principle rafters and purlins altogether and construct the roof by resting common rafters directly on the postplate. In that case a precaution is necessary, *viz.*, that a rafter of greater thickness should be notched on the top of the postplate at every six or seven ft., and if necessary the postplate and the thicker rafter should be connected together by means of a $\frac{3}{8}$ inch thick flat strip of iron bolted to both as shown in fig. No. 151. If this precaution is not taken it is likely that the posts may go out of plumb on account of the weight of the inclined roof which may either push the top out or pull it in.

(2) *Gabled roof*:—In its simplest form it consists of common rafters on either side notched and nailed on to a central ridge, the latter resting on the appices of triangular walls at ends. The end walls of a gabled roof are raised high above the side walls to a triangular shape to meet the underside of the roof.

(3) *Hipped roof*:—Unlike in a gabled roof, the end walls of a hipped roof are not raised above the side walls to form a triangle, but are kept at the same level as the side walls The hipped roof has four wings instead of two as in the case of a gabled roof, the two at the ends being triangular in shape and sloping. The rafters at the corners which are called "hip rafters" are fixed midway, *i.e.*, at 45° angle to the sides, in plan. As the length of a hip rafter is greater and as it has to carry more weight it must be sufficiently strong, and if it is longer than say, 18 ft, it has to be supported midway by some means.

Parts of a roof.—These are. common rafters, hip-rafters. purlins. ridge, and trusses.

Common rafters are generally laid at 1′-6″ apart centre to centre, their width should be $\frac{1}{8}$ inch per ft. of length and thickness or depth double this, with a minimum width of $1\frac{1}{2}$″ and depth 3″.

The width of a hip-rafter should be $\frac{1}{4}$″ per ft. of length and depth, double this. It should rest on a piece of wood laid diagonally across the two walls of the corner.

The width of a purlin should be $\frac{1}{8}$″ per ft. of its span and the depth $\frac{1}{2}$″ per ft.

A ridge is fixed between the upper ends of common rafters which abut against it on both sides, hence, it does not require much width, but its depth should be $\frac{3}{4}$″ per ft. of its span. The width is generally 2 to $2\frac{1}{2}$ inches.

The trusses commonly used in buildings of ordinary type are of three kinds, *viz.*, (a) Collar beam, (b) King post, and (c) Queen post. Trusses are laid usually 8 to 10 ft. apart centre to centre. In exceptional cases they are laid at a maximum distance of 12 ft.

(a) Up to about 8 ft. span no truss is required. Beyond 8 ft. span the rafters are likely to bend at centre under the load, hence they are supported by a collar, which consists of a piece of wood fixed horizontally at the centre of the principle rafters, as shown in fig. 153 If the span exceeds 12 ft. there is a tendency on the part of the ends of the truss resting on the walls to spread out under the load and exert a push or a thrust on the walls towards the outside. To pre-

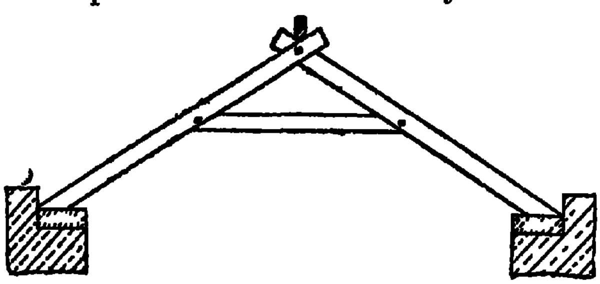


Fig. 153

vent this an additional piece of wood parallel to the collar is fixed to tie the end of the truss. Since this piece exerts a force of the nature of pull instead of wood, a rod or a flat strip of iron would do equally well. This is shown in fig. 154 in which an additional vertical rod also is employed at the centre to pull the collar beam up, *i.e.*, to prevent it from bending down or sagging.

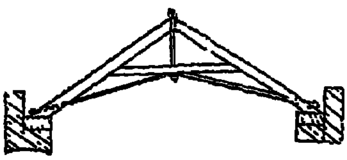


Fig. 154

Sometimes instead of one thick piece of wood two thin planks are used on both sides to form a collar. These are joined by means of bolts.

(a) *Collar beam* trusses possess one advantage over other trusses, *viz.*, that since the collar is at a higher level the truss provides a greater headway. This advantage can still further be increased by providing corbels, *i.e.*, projecting stones built into the walls and resting the truss consisting of two vertical posts close to the walls, two principle rafters, and an arched shaped collar joining the posts and the principle rafters as shown in fig. 155. This arrangement increases the headway still more, looks more elegant, and makes the truss useful for spans even upto 30 ft.

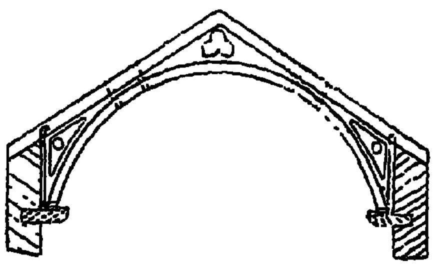


Fig. 155

(b) *King post truss* :—This truss is used for spans from 12 to 30 ft. This differs from the collar beam truss in this, that instead of a collar there are two struts to support the principle rafters at their centres. Further, there is a tie beam at the

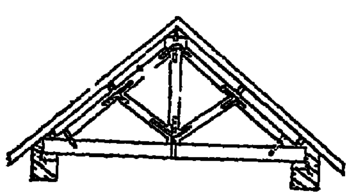


Fig. 156

bottom to prevent the ends of the principle rafter, from spreading out and exerting a thrust on the walls. In addition to these the central vertical member, which is called the "king", prevents the tie beam from sinking down under its own weight (Fig. 156). Both the tie beam and the king are tension members, *i.e.*, they exert a pull Therefore, they can be replaced by either rods or flat strips of iron. This is shown in fig. 157. Another kind of king post truss in which a combination of timber and steel is made is shown in fig. 158.

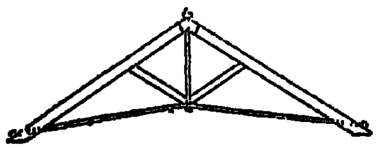


Fig. 157

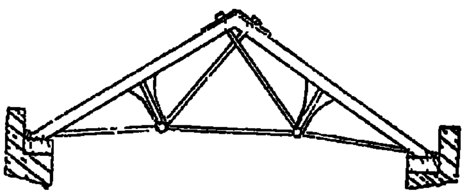


Fig 158

(c) *Queen post truss*:—When the span exceeds 30 ft. a queen post truss is employed. This is illustrated in fig. 159.

In a large hall, when large crowds of people congregate, for driving out the used air which gets heated and rises to

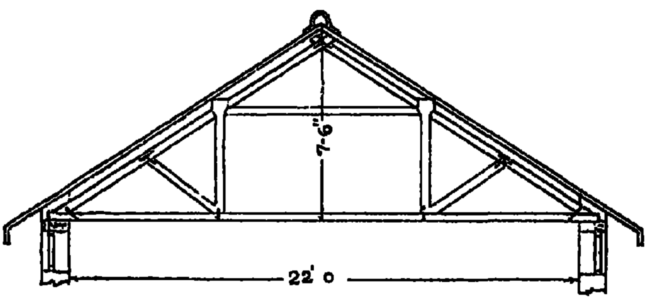


Fig. 159

the top, ridge ventilators are provided parallel to the ridge on both the sides as shown in Figure 160

Roof-Covering.—The ideal material for the top covering of roofs should be (1) thoroughly water-proof, (2) fire proof, (3) light and durable, (4) cheap both initially and in upkeep, (5) capable of being easily laid and repaired, (6) affording

perfect protection from the heat of the sun, and (7) matching the architectural appearance of the building

The materials generally employed are ·

(a) Thatch (b) Flat country or pan tiles (c) Half round country tiles (d) Mangalore pattern tiles (e) Corrugated sheets either of iron or asbestos cement (Trafford Sheets) (f) Patent rubber or similar sheets and (g) Slates.

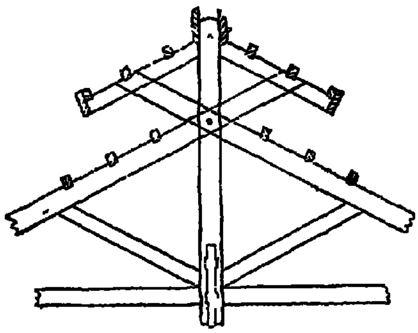


Fig 160

(a) *Thatch* is the cheapest and lightest material and when properly laid in sufficient thickness affords the best protection from the sun and rain But it is inflammable, absorbs moisture, rots and gives out foul smell harbours rats, does not allow any ventilation, as there are no crevices, and has to be renewed every second or third year.

(b) and (c) *Pan and half round* country tiles absorb heat and radiate it in rooms below. Besides, as they are small in width and heavy, they require rafters one foot apart and closer battens, which increase the cost. Thirdly, the tiles have to be turned every year and a large number of broken ones replaced.

The tiles should be well burnt and should not absorb more than $\frac{1}{8}$ of their weight of moisture. The rafters below them should be straight, and if slightly bent, packing of wood should be nailed in the hollow of the bend. The lengthwise overlap of country tiles should be a minimum of 2″ and the ends of the tiles at the end of the down slope or near the 'eaves' should be set in mortar which prevents them from sliding down.

(d) *Mangalore pattern tiles* are lighter and larger in size and thus require rafters 1′-6″ apart. But these must be

of sawn wood. Round rafters which are likely to be crooked are unsuitable. As the tiles are light, they are likely to be blown away by wind. The remedy is to provide ceiling below. Providing a ceiling only below the portions projecting beyond the walls also helps considerably. Since the wind striking against walls horizontally, when obstructed by walls is directed upwards and causes the tiles in these portions to be blown away. Another remedy is to fix the last horizontal row of tiles near the eaves to the bottom below, either by screws or wires.

Sometimes, ceiling of wooden boards or corrugated iron sheets is provided below for mitigating heat. In that case it is advisable to first nail battens 2" x 1½" on edge, parallel to the slopes at 2½ ft. intervals, then the usual battens of 1½" x 1" across these, and lay tiles on the latter. This provides an air space of 2" between the tiles and the ceiling, and air being non-conductor of heat, the rooms are maintained cool at a small extra expense.

It is a mistake to fix the ridge tiles in lime mortar. Once they are fixed, the watering on the work though more necessary at least for two weeks, because it is exposed to the sun, is usually neglected at such an inaccessible place with the result that tiles remain loose and give trouble by leaks. If cement mortar is used, watering for the first day or two only might develop sufficient strength.

(e) *Corrugated iron or trafford sheets*: Corrugated iron sheets are available in 6 to 10 ft. lengths, of 26" to 32" width and of 18 to 26 gauge (thickness). 18 gauge sheet is the thickest.

Corrugated iron sheet roof is very light and so requires timbers of smaller section, wider apart. The purlins should be 3 to 4 ft. apart. The lengths of sheets should be so adjusted that the joint comes on top of a purlin. The minimum over-

lap should be 4″ length-wise and 2 inches, or 1½ corrugation width-wise. This is very important if the slope is flat. The holes for fixing sheets should be punched on the ridge of the corrugation and not in a hollow This warning is seemingly unnecessary, but majority of carpenters are careless about it. Similarly carpenters are prone to drive galvanised screws *by hammering* into purlins, which makes the sheets loose and liable to be blown away. The screws should be fixed by turning by a screwdriver into the holes previously punched by another tool.

Corrugated iron sheets are liable to get rusted by salty, sea-borne breeze. The preventive remedy is to give two coats of bitumen, or lead paint on both the sides and renew it every second or third year

Corrugated iron sheet roof has two great disadvantages, *viz.*, (i) it makes the rooms hot and (ii) being very light it is likely to be blown away by wind.

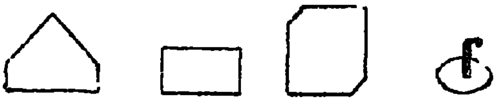
The remedies for these have been discussed at great length in the author's "Cheap and Healthy Homes for Middle Classes."

Asbestos cement sheets suitable for roofing are available in two varieties (i) with corrugations close together like those of c.i. sheets and (ii) with wider channels. The latter are either red or grey in colour. Though a material which does not conduct heat, *viz.*, asbestos, goes into the composition of the sheets, on account of their thinness, heat is not mitigated They are breakable, heavier and slightly costlier than c i sheets but they look neat and clean and their colours—either grey or red harmonises more with domestic architecture than that of c.i. sheets.

(f) *Sheets of rubber* are unsuitable for tropical conditions. They are likely to crack very soon by extreme heat

Sheets of plastic materialli ke asphalt are not so easily affected by heat, e.g., asphaltic felt are better but they too soon deteriorate.

(g) *Slates* :—Except in a very few places they are not much used in this country. They are smooth, hard and non-absorbent of moisture, but absorb more heat and are heavy, requiring stronger timbers. The slabs are usually $15\frac{3}{4}''$x$15\frac{3}{4}''$ in size (Fig. 163) and are fixed on battens $1\frac{1}{2}''$ x $1''$ nailed to rafters at $9\frac{1}{4}''$ centres. The batten at the eaves should be at $7\frac{3}{4}''$. The first row near the eaves should be of slabs $15\frac{3}{4}''$x$7\frac{3}{4}''$ (Fig. 162) on top of this is fixed a row of triangular slabs as shown in figure 161 and on the top of the latter, the square pieces. The half pieces and triangular pieces are fixed by galvanized wire or nails and the squares by copper nails fixed in the centre of a copper disc. (Fig. 164) into holes drilled in corners of tiles. The pins of copper nails are turned at top. Fig. 165 shows the process of laying tiles at different stages.



Figs 161, 162, 163 & 164

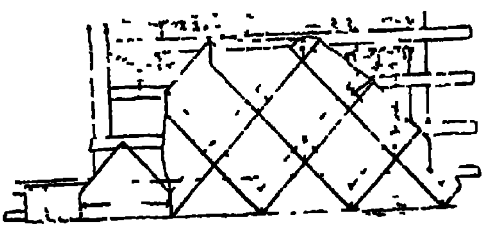


Fig. 165.
Slate Roof.

FLAT ROOF

With the common use of R C.C flat roofs have recently come more into prominence. There are two types (i) just a thin concrete slab on top of walls with a slight slope on the top surface to drain off rain water. Such slabs usually project a foot or two beyond walls on all sides (ii) Flat terrace roof designed for use as an out-door living room.

The difference in cost of the two is not much Yet the second type provides an extra accommodation at a high level, full of privacy, which is a great blessing in tropical countries in particular. Another advantage claimed for flat roofs. viz., that it keeps the rooms below cool, is doubtful since the thickness of the concrete roof scarcely exceeds six inches. which is not sufficient for the purpose. A third real advantage is that it simplifies the design of roof. To construct a sloping roof on the top of large rooms, consistent with economy and architectural considerations is often a very difficult thing. One more advantage it possesses in the days of modern warfare is that it is proof against incendiary bombs.

Against these may be set off the following disadvantages :-

(i) On account of extreme variations in temperatures in India, hair cracks are bound to occur on the surface which cause the leak trouble.

(ii) A leak in a flat roof is very difficult to trace and set right. Whereas a leak in a tiled roof is very easy to be remedied.

(iii) A flat roof exposes the entire building to the elements, whereas the projecting eaves of a tiled roof tend to keep the house dry.

(iv) A leaky flat roof may be a source of danger to a house with walls of mud or in mud mortar. For, the gutter behind the parapets comes exactly on the top of the

walls below, and water may leak in them through cracks in the gutter.

All the above objections except the 3rd are based on the assumption of unsound construction of a flat roof. With modern materials and researches it is possible to make a perfectly watertight terrace at a slight extra expense and this little extra cost is certainly justifiable when the advantages are weighed against it. The best course is to choose a golden mean, *i.e.*, to construct tiled roof on part of the building and a flat roof on the remaining.

The cheapest and reasonably watertight terraced roof can be made if there is "white earth" obtainable at a cheap rate. This white earth is a sort of *"*Khari Mitti*" and is impervious to water. It is found in and around towns and villages. where, by constant treading by people and cattle and by the action of manure attains this property of imperviousness to water. Round *ballies*, either of teak or sal, are nailed to wooden beams. Upon these are spread some sort of reeds or wattle such as *Sarkand* or *Samalu* in Northern India, or *Karvi*, bamboos or stems of palm leaves in Southern India, or timber waste, closely nailed together, and on this is spread a 6" layer of stiff mud of white earth which is beaten hard. If white earth has to be transported from long distances, mud of any earth which contains sand or silt and does not crack, is good enough, but it would require a layer of one to two inches of dry loose white earth on top.

Better class people who can afford, should lay mild steel T pieces in an inverted position one foot apart with their ends resting flat on beams and lay special roofing baked clay tiles 12"x6"x2" on the flanges and over these should be spread another layer of tiles in mortar breaking joints and

* The process of making white earth artificially from any earth is described in detail in the Author's "Cheap and Healthy Homes for Middle Classes"

on them a layer of stiff mud and an inch or two of loose white earth for the topping.

Even though such roofs crack badly in hot weather, the cracks are automatically filled when the first showers of rain carry some loose earth into them and render the roof perfectly water-tight.

In villages and small towns if C.I. Sheets are given two coats of coal-tar and laid simply to rest on beams (and not fixed by nails or screws) and if a 6″ layer of mud and loose earth as above is spread on them the roof would not only be perfectly water-tight, but heat-proof and permanent. Slight surface slope should be given.

Concrete terraces :—These require an absolutely rigid sub-grade. If the frame-work, for resting concrete terraces upon, be of wood, cracks and leaks are bound to occur. For, wood swells in moist weather and shrinks again in the hot season and causes movements in the concrete. In old times they used wood, but the thickness of terraced roofs used to be at least one foot. It is advisable to use steel beams or joists for concrete terraces, or R. C. C work. On the top of jack arches, or tiles or stone slabs there should be a layer of at least 4 inches of concrete made of $2\frac{1}{2}$ parts of brick-metal, one part of unscreened sand and at least $1\frac{1}{2}$ parts of lime mortar. The concrete should be beaten well for three days and during the process of beating the surface should be sprinkled with water, in 6 gallons of which, should be dissolved one seer of molasses and $\frac{3}{4}$ seer of *bael* fruit Finally clean water should be sprinkled and when the cream of lime which rises to the surface is softened it should be trowelled to bring out a smooth surface. No cement nor lime should be used, as it would form a skin layer which would soon crack.

If the above process is adopted an excellent floor—hard, durable and water-tight, would be formed. But due to any

defects in construction, or use of less quantity of lime mortar in the concrete, the floor leaks. a thick coat of bitumen should be applied by a brush, upon which dungry cloth (khaddar) soaked in bitumen should be spread and well stretched to remove wrinkles, and another coat of bitumen applied, and sand freely sprinkled on it and the surface rolled. After three or four days the excess of sand should be collected and removed.

Another simple method of making a water-tight terraced roof is to lay flag stones of as large a size as available (to reduce the number of joints), in the usual way on a lime mortar bedding leaving joints at least $\frac{3}{4}$ inch wide. As soon as the paving is done, the mortar from the joints should be raked out and substituted by cement mortar, of one part of cement and three parts of fine sand.

In this logical method there is very little possibility of leaks occurring. For, in the first place the joints are few and they have received a special treatment with cement mortar. Still if in course of time some hair cracks do appear, and through them water trickles, it is an easy matter to break the particular joint or joints by a chisel and fill them half their depth with bitumen or asphalt and to make good the upper half with sand. The bitumen will slowly rise and be mixed with the sand and make the floor perfectly water-tight. The purpose of keeping wide joints is to enable them to be broken with a chisel.

The process of making an asphalt floor has been already described on pages 196 and 197.

PAINTS, VARNISHES AND DISTEMPERS

The purpose of applying a paint is to protect the material from air, moisture and gases. It prevents the decay in wood and corrosion in metals. It also provides colouring and hides the surface, and by giving a gloss and smoothness to the surface brings out a decorative effect.

A paint essentially consists of two things (1) a base of solid matter which supplies "body", *i e.*, opacity by obscuring the surface and (2) a liquid vehicle which carries the solid matter and allows it to be evenly spread on the surface. The vehicle forms a binder for the solid matter and adheres to the surface.

The base may consist of either white lead, red lead, zinc white, oxide of iron, or graphite, with or without a pigment or colouring matter. White lead is the most common material in use, since it is cheap and possesses the advantage that it is easily applied and has a good "body," but it turns yellow or brown and thus loses its decorative effect, by exposure to air containing fumes of sulphur present in homes where coal is burnt, or in industrial towns. White lead is often adulterated with barium sulphate.

Zinc white is free from the above objections and retains its whiteness throughout, but is costly, requires several coats as it does not possess "body," and is not lasting.

A combination of both these, i.e., the first or priming coat of white lead and the finishing coats of white zinc, gives good results, particularly on wooden or plastered surface.

Red lead is the best for painting iron surface, to which it sticks well and protects it from rusting.

Vehicle :—The usual material is linseed oil. Raw linseed oil is thin, but takes a long time to dry. It is, therefore,

boiled and during the process a drier, like litharge is mixed. It then becomes thicker and darker in colour and hardens in 12 to 24 hours. For delicate work either raw linseed oil, which is thin, is used with driers, or poppy or nut oils which are costly, may be used. Boiled or double boiled linseed oil is more suitable for paints on plastered or metal surface. For wood work, if the original colour and grains are to be preserved, raw linseed oil is preferable.

With vehicles, especially with boiled linseed oil which is thick, a thinning agent—usually turpentine is used just to serve as a solvent and thinning agent to facilitate spreading evenly on the surface. It helps also in the penetration of porous surface like wood or plaster. But at the same time it reduces the gloss of the linseed oil. It should be most sparingly used, particularly, when the preservation of metal surface is the object.

Driers :—Litharge or oxide of lead is very common in use, the proportion being $\frac{1}{4}$ lb. to a gallon. Zinc sulphate and red lead are also often used. Driers absorb oxygen from the air and impart it to the linseed oil, which, in consequence, sets hard, somewhat like cement. Driers, however, destroy the elasticity and therefore should be sparingly used especially in the finishing coat.

The pigments or colours may be either (a) Natural earth colours such as ochres, umbers and iron oxides, (b) Calcined colours like carbon black, lamp black, venetian and Indian red, ultra marine, etc. (c) Precipitates like chrome yellow, Prussian blue, Brunswick green, etc. or (d) Lakes.

Preparation of paints :—The base should be first thoroughly mixed in oil to the required thickness and a little spirit of turpentine added. The colour should then be ground on a flat stone in oil until thoroughly mixed and then made

thin by adding oil and turpentine Both these should then be mixed together, strained through khaddar cloth and used with good brushes

Preliminary treatment.—The wood should be well seasoned and dry, all the knots should be filled with Russian tallow, or putty (made of linseed oil and equal parts of white lead and whiting). The surface should be cleaned of all dirt and dust.

Steel surface should be cleaned of all dirt and dust and should be scraped to remove all loose rust or scales of old paint and scrubbed with a wire brush

Plastered surface and brickwork should be first brushed of all dust. It should then be given a coat of sizing (glue mixed with water). This serves two purposes (1) it fills all the small cracks and dents and (2) it reduces suction Otherwise. all the oil in the paint would be sucked up and dry patches of paint left on the surface. Painters, in majority of cases prescribe a coat of linseed oil, if the paints are supplied by the owner. But this is very costly A coat of oil is good on non-absorbing surface.

Priming coat:—This is the most important coat. (a) It fills the pores in wood and small dents in iron (b) Adheres closely and forms a key to the next coat and (c) prevents absorption of the vehicle of the next coat. Hence, it should be properly applied of good material and not—as is frequently the case—the remnants of old paint cans. It should be a little thinner than the subsequent coats.

Brushes:—The success of painting depends as much upon good brushes as on paints. The brushes should be of bristles and not of horsehair. The latter lack the elasticity, wearing quality and paint-holding capacity which bristle brushes possess. Bristles can be distinguished from horse hair as

each bristle is split at ends. Further, horse hair curls up, while bristle remains straight. A good brush should have springiness in bristles. A round brush is considered the best for painting. But the painters in this country are generally fond of flat brushes.

Applying paint:—There should be plenty of mixed paint on hand. If too much is mixed it can be used up as under coats elsewhere. Painting should be started from the top and progressed downwards. The paint should be finished over by drawing the brush along the entire length of small surfaces so that no breaks are visible. The work should be done sufficiently fast so that one portion of a surface will not have dried before the next is taken in hand.

Only one-third the length of the bristles should be immersed in the paint and the excess paint should be removed by gently rubbing the brush against the inside surface of the pail. The brush should be held at right angles to the surface and only the ends of the bristles should touch the surface.

A few practical hints on painting:—

(1) As far as possible painting should not be done in damp weather and never on a damp surface

(2) Painting should not be done on a freshly plastered surface Let it age for at least 12 months. Otherwise, the alkalis in the plaster would bleach and discolour the paint.

(3) The surface which is to be ultimately painted should not be tarred. A coat of tar even though old. "bleeds" through the coat of paint and spoils it.

(4) Old brushes should be kept either in water, or raw linseed oil (covering the bristles only) when not in use

(5) New galvanised metal surface does not take a paint It should, therefore, be washed with hot water in which 1 lb of washing soda is dissolved in a bucket.

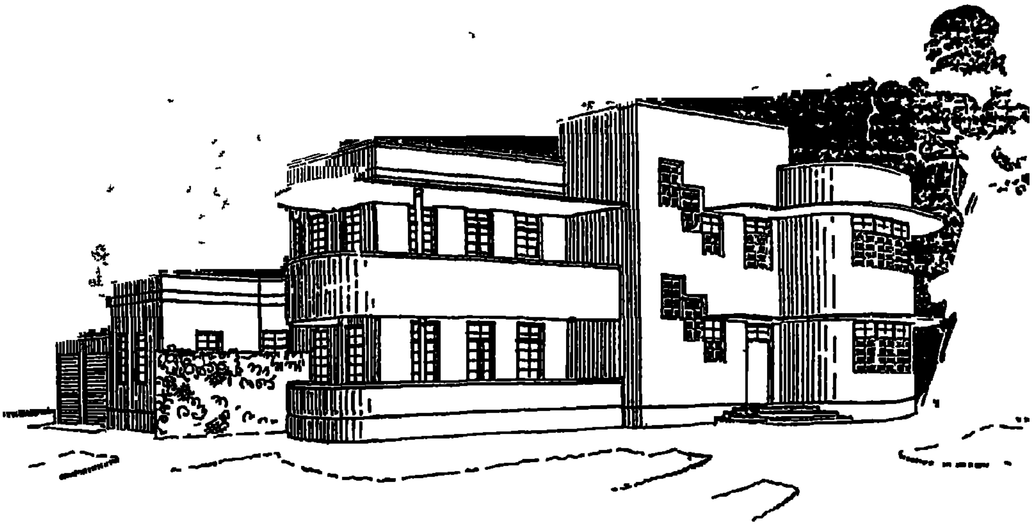


Fig. 166
A Handsome Villa.

VARNISHING

Varnish is generally used for indoor surfaces. It may be used either alone or mixed with a paint for the finishing coat. It protects the surface and gives a gloss to it.

Preparation of varnish is a difficult thing. It is, therefore, advisable to buy ready-made varnishes. There are several firms now in India who manufacture varnishes. Two easiest methods are given below :—

1. Crush 3 lbs. of resin and dissolve it in 2½ pints of sprits of turpentine, shake well from time to time and after two days, add 5 quarts of best boiled linseed oil and the necessary quantity of turpentine required for thinning it at the time of application

2. In the same way as above prepare varnish with 3 parts of copal (*Chandras*), 4 parts of spirits of turpentine, and 3 of linseed oil

There is a variety of varnish called white oil varnish, which is very pale and almost colourless and is suitable for varnishing interior decoration and furniture. It brings out the original grain and colour very effectively.

Before applying a varnish the surface is prepared just like that for painting by removing dirt and dust, filling knots, nail holes etc. and rubbing it with sand papers.

Simple oiling is most economical and is also effective both in protecting the surface and making it glossy, particularly if extra good quality of linseed oil, which dries up like varnish is used. The process is this: Take 3 lbs. of best double boiled linseed oil, put one lb. of bee's wax in it and boil, stirring it well till the wax melts and is dissolved. After it is cooled, add one lb. of turpentine. Apply with a rag in two coats.

French polish :—Varnish is thick and coloured and obscures the original grain and colour; it is likely also to be scratched. Hence, very often French polish is applied.

The surface should first be sand papered. Then a coat of one of the filler compounds given below should be applied. A suitable colour or pigment should be used in the filler compound which would give a tint of the final colour of the surface desired. Filler compounds: (a) whiting mixed either with water or with methylated spirit (b) Plaster of Paris mixed either with water or linseed oil (c) Linseed oil and bee's wax, boiled together applied sparingly with a rag dipped into turpentine. When the filler coat is dry rub the surface with sand paper and apply the coats of the French polish The latter is prepared thus :—

Dissolve 3 lbs. of black or light brown shellack (according to the required colour of the polish) in 12 bottles or two gallons of methylated spirit, keep well stoppered over night and add powders of gamboge (*Reva-Chinika Sira*) ¼ lb, Copal (*Chandras*) ¼ lb.. Lobana or *Mogali Bedana* ¼ lb and one tola of the crystals of the necessary colour e g. Mahogani, light chrome, dark, seesum etc. stir well and apply with a rag. It dries up in 2-3 minutes. The surface should then be rubbed again lightly by sand papers used previously. The sand paper used should be of 0 or 00 number It should then be wiped with a dry cloth and the process repeated several times in succession. The surface becomes progressively shiny.

Cautions :—(1) French polishing should not be attempted in damp weather if good results are desired. (2) Tea kettles and other hot articles should not be kept in contact with French polished surface. (3) French polished surface should not be washed with water. At the most it should be gently wiped with a just moist soft cloth.

White-washing, colour washing and distempering.

Preparation of surfaces:—The surface should be clean and thoroughly dry. If it is extra smooth, coats will not stick to it. In that case it should be lightly rubbed with a sand paper. For re-white-washing the surface should be cleaned of all loose old wash and sand papered, all nails removed and holes filled with lime putty in which the same amount of fine sand and a little gur (*Jagherry*) is mixed. Otherwise, cracks due to shrinkage would appear. If the patches are large, the wash should not be applied until they are reasonably dry.

Application:—The wash to be applied with a brush in two coats—one vertical and the other horizontal. Each coat must be allowed to dry before the next is applied. Three coats are required for new work and for work on scraped surfaces. Annual white-wash may consist of one coat only applied first in vertical strokes of the brush followed immediately by horizontal strokes.

Materials:—For white-washing fresh quick lime in unslaked condition is required. Lime obtained by burning shells in a kiln should be preferred as it is white and free from impurities. It should be put into a tub and plenty of clean water poured on it. When slaked it should be stirred and thinned by adding water to a consistency of cream. It should be then strained through khaddar. Then a solution of either one lb. of gum arabic or glue dissolved in water, or size, made of one lb. of rice flour, should be added to one cft. of the liquid.

A little blue or *tootia* (copper sulphate) if added prevents glare and gives it a pleasing effect.

A little alum, say, $\frac{1}{4}$ lb. to a cft. of liquid wash, if added, causes it to stick well.

In kitchens where the walls have become discoloured by smoke a wash of a mixture of wood ashes in water should be applied before a new coat is given.

For preparing a colour wash, the necessary pigment or colour is to be added to the white wash prepared as above with gum, glue or size. With some colours rice size causes streaks, it should, in that case, be substituted by a gum or glue. A cheap buff wash may be prepared by adding "*Peeli*" or Multan *mitti* also called "*Ramraj*" in Northern India.

A cheap light olive green wash is made by adding a paste of crushed droppings of goats in water after straining it in a coarse cloth. It may be objected to, from a sanitary point of view, but when dry it is no more harmful than cow dung.

For a slate colour add lamp black and blue.

For a green wash, boil about 10 lbs. of fresh mango bark in 4 pints of water for 5 minutes and mix the water together with a solution of 2 lbs. of copper sulphate (*Tootia*) in 3 pints of boiling water.

Sufficient colour wash should be prepared to cover a room at a time and never more than the quantity required for one day.

Distempers are obtainable ready-made. They have one advantage that the shade is uniform. But they are costly. Some of them are really "washable", *i.e.*, the surface distempered can be cleaned by rubbing it lightly with a soft cloth dipped into clean water. This should not be done within three months of applying the distemper. It takes that period to set.

Latrines may be divided into three classes :—

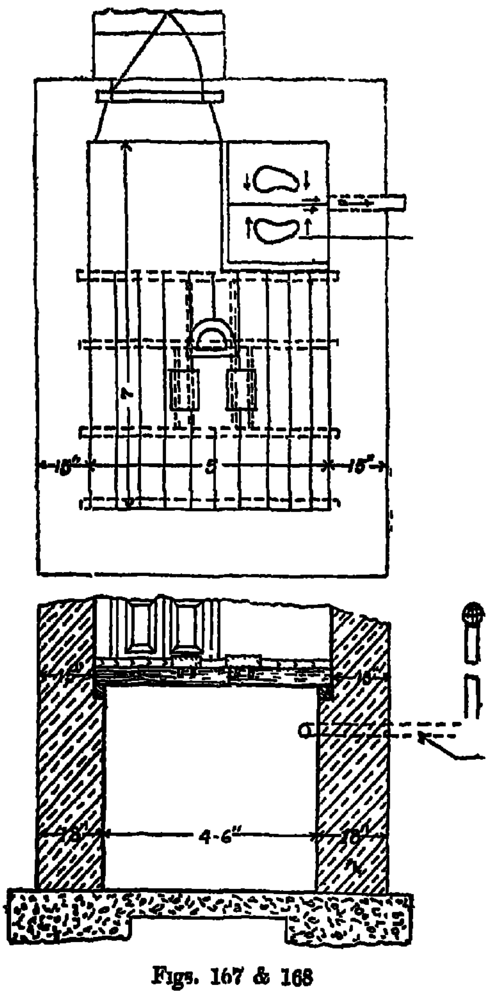
(1) In villages where there is no Municipal or some such local organisation to control the sanitation, but where there is plenty of open space round or close to the house. Here *earth closets* are very suitable.

(2) In towns where the Municipal bodies have employed scavengers for removing night soil, latrines on the basket or pail system are built.

(3) In cities where adequate water supply is provided and underground sewers are built water closets on the flushing system are built.

(1) *Earth closet*

In India on account of two disabilities, viz., that on account of heat, putrefaction starts very early and that lot of water is used for ablution, the problem of earth closets becomes a little more difficult than in the Western countries. However, if an earth closet is built on scientific lines and arrangement is made to separate liquids from the solid excreta or at least to reduce the quantity of water to a minimum, it must give perfect satisfaction.



Figs. 167 & 168
Plan and section of Earth Closet

The type of an earth closet shown in figs. 167 and 168 has been found by experience to give excellent results. It consists of a pit 4′-6″ x 4′-6″ and 4 to 5 ft. deep with

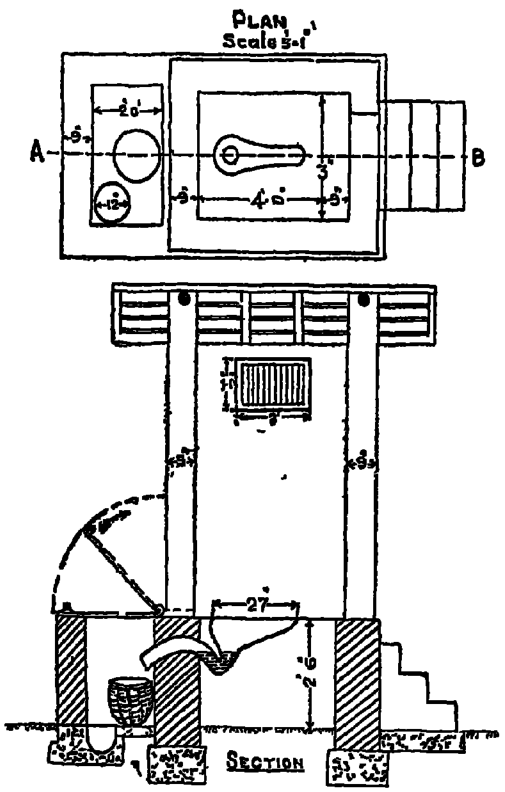
6″ of lime concrete at bottom and 18″ thick side walls. The pit is lined at bottom and sides with cement plaster. At the plinth level the thickness of walls is reduced to 15″, leaving a step or an offset of 3″ inside all round. On this ledge a wooden frame is placed and a rigid platform is made of one inch boarding, leaving a gap 7″ wide with foot rests on both sides for squatting and a suitable basin with a hole at bottom for the urine. On the front side near the right hand corner there is a sink with foot rests with good slope towards a central channel for ablution purposes. As soon as the closet is used a mixture of dry earth and ashes placed in a pail near the seat is to be spread by the person to cover the excreta and then the ablution should be done in the corner sink The water from the latter is diverted from the earth closet and treated separately in a soak-pit about 3 ft. deep filled with rubble stones, brick bats gravel etc. and covered with six inches of earth at top. There is a ventilating pipe provided. But this is not absolutely necessrary.

As only the urine is admitted into the pit the quantity of earth required to treat the liquid portion is small and if sufficient quantity of it is used there are absolutely no foul gases produced.

(2) *Latrine on the basket system*

Here is an improved design of a latrine on the basket system shown in figs. 169 and 170. The outstanding feature is an earthen ware closet just below the seat to receive the liquid and solid excrements and also the ablution water. The pre-war price of it was Rs. 8/-. It is white glazed on the inside and has a sloping bed so that the contents slide into the trap below, which is normally filled with water up to a certain level. The ablution water causes the excreta to be carried through the trap into

the basket placed outside the wall into a chamber. There is no connection between the seat side and the basket side except through this trap which being always filled with water no foul gases from the basket can enter the closet. As the basket is hidden from view, the contents are not seen by the user.



Figs 169 & 170.
Plan & section of improved latrine on basket system.

The chamber on the outside which is 2′ x 3′ has the bottom and sides lined with cement plaster and contains in a corner a small pit or a sump to which all the liquid is led by a suitable slope. There is a hinged cover of steel provided on the chamber. The basket is provided with a fairly deep layer of fine coke-breeze mixed with ashes so as to act as a kind of filter. Failing to obtain this, porous earth may be substituted. The sweeper's business is to lift the cover, remove the basket, scavange the floor, remove also the liquid contents of the pit and replace the basket putting fresh coke breeze or earth in it and close the cover. The efficiency of the arrangement is due to the facts that,

(1) As the chamber is always covered, no flies will sit on the filth.

(2) The solid contents are at once separated from the liquid and thus do not readily putrefy and can also be easily removed and basket cleaned.

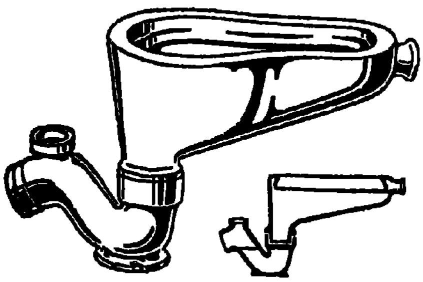
(3) The liquid, since it filters through coke breeze or earth does not give out foul odour

(4) The whole thing remains quite clean and hidden from view.

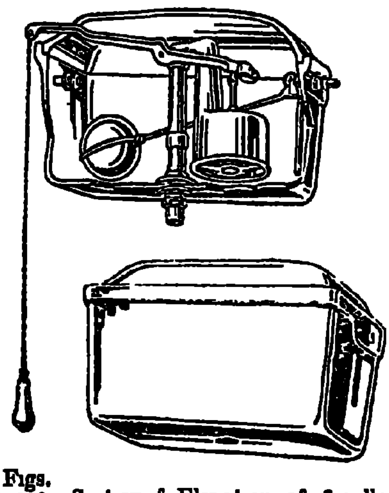
(3) *Water closet*

Amongst all the forms of latrines the water closet gives the most satisfactory service. These can be allowed even inside the house. The requirements of this system are that there must be plenty of water at a sufficient head and adequate means of disposing of the sewage.

Figs. 171 and 172 show an elevation and a small scale section of the same type of an Indian W. C. pan. It consists



Figs 171 & 172.
Indian type water closet pan with trap



Figs. 173 & 174. Section & Elevation of 3-gallon flushing cistern of chain pull type

of two parts, joined together by cement. The upper one is the pan which is fixed in the socket of the lower part, viz., a trap. On the left hand side of the trap there is a projection on the top, to which an anti-siphon and ventilating pipe is usually connected. The projection in front of the pan on the right hand side is provided for connecting a pipe from a 3-gallon flushing tank provided with a chain pull Figs 173 and 174 show an elevation and section of such a tank.

HOUSE DRAINAGE

From the point of view of the preservation of health the question of house drainage which forms one of the important parts of general sanitation and hygiene is of the greatest importance. However, it rarely meets, in India, the thought and care which it deserves. In most cases, what is out of sight is out of mind and there is a general tendency to neglect this matter, until by contaminating water supply or bringing infection of disease in a family it actually proves a source of great danger, when it may be perhaps too late to rectify matters.

Before proceeding to describe in brief detail, the general principles and practice of laying house drains it would be advisable to first consider the special materials and fittings required for a perfect drainage system.

The general principle in selecting materials is that the surface should be very smooth, so that nothing sticks to it. It should also be non-absorbent and proof against the action of acids and gases—particularly sulphurous gases which are likely to be given out by sewage under putrefaction. Further, the passage for the flow of liquids should be smooth, free, unobstructed; no sharp bends, no contractions and no sudden expansions are allowed. The whole arrangement should be such as to allow every facility for inspection, removal of obstructions and repairs.

Stoneware pipes :—These are of clay, but are called stoneware pipes. These should be well burnt, salt-glazed so as to be very smooth and non-absorbent, straight and perfectly round, free from any cracks. They should ring when struck. They are usually 2 ft. long with one end plain (Spigot end) and the other with a collar (socket end). Municipal byelaws require a minimum of 4 inch drain to be adopted for house drainage. The pipes are joined together first by mak-

ing a concrete bedding 12″ wide and 3 to 4 inches thick, then inserting flax or jute dipped into cement paste, round the spigot end and then caulking cement forcibly round and making a wiped joint. The minimum fall required for 4″ pipes is one ft. in a length of 40 ft. and for 6″ pipes one foot in 100 ft. The direction of the flow should be from the socket end towards the spigot of each pipe

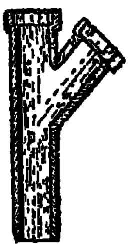


Fig 175. Stoneware "Y" junction pipe.

The special fittings usually required for a pipe line of S. W. (Stoneware) Pipes are: bends, "Y" junctions, "T" junctions, elbows, gullies or gully traps, siphon traps, half-round channel, etc., some of which are shown in figs 175 and 176.

Cast iron pipes :—The minimum size is 2″ diam. and they are available in 6 ft. lengths with spigot at one end and socket at the other. Cast iron is likely to corrode, hence only those pipes which are treated with Angus Smith process during manufacture, viz., dipping the pipes while hot into bitumen should be used. The minimum diameter used for waste water from bath, kitchen, etc., and rain water is 2 inches and the minimum for carrying sewage is 4 inches. The latter are called soil pipes and are thicker. There are a number of special fittings such as plain and 'S' bends, offsets, 'Y', 'V' 'T' and tripple junction, *Nhani* trap etc.—inspection chamber covers with frames etc. As far as possible bends which have plugs at top and which can therefore be opened for cleaning should be used. The joining of pipes for carrying sewage or water supply is made by either molten lead or lead wool, that of rain water and other S W. pipes by cement.

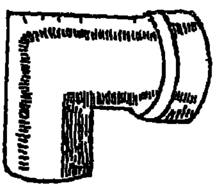


Fig 176 Stone ware elbow.

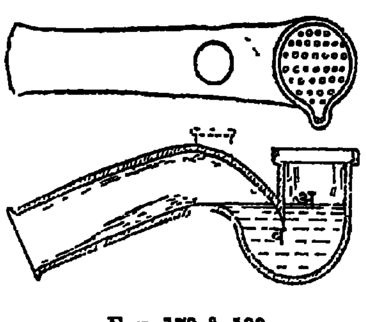
Figs. 177 & 178 Cast iron Nhani trap plan & elevation.

Lead Pipes :—These are costlier than either stoneware or cast iron pipes, but they neither rust nor are affected by acids. Besides lead being flexible can be bent to any shape and jointing also is very easy as the metal fuses at low temperature.

Hume Concrete Pipes :—Of late, pipes of concrete are manufactured in India from 4″ to 72″ diameter. As they are manufactured by the process of spinning, the inside surface is very smooth. Large diameter pipes are reinforced with steel inside.

Asbestos cement pipes :—These are also of Indian manufacture. They are comparatively light and their grey colour very often harmonizes with the architecture. They are from $2\frac{1}{2}''$ to 6″ diameter and all the accessories such as bends, plug bends, "Y", "T", "V" junctions, half round channels, gutters, sinks, etc., are also available.

Traps :—The object of traps is to prevent the passage of gases from the sewer from entering the house. It consists



Figs 179 & 180
Plan & section of D-type cast iron Nhani trap

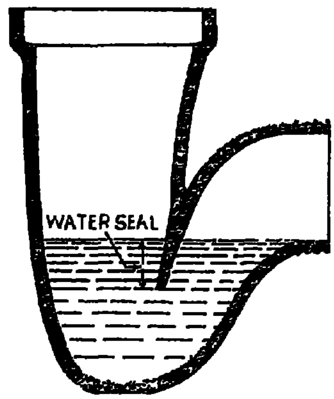


Fig. 181
stoneware Gully Trap

of a depression or a hollow in the lower part of a fitting to collect and retain water. A tongue or a lip is provided, projecting and terminating a little below the water surface, so that it allows the passage of sewage, but the pond of water

formed in its bottom prevents the escape of gases from the outside of the lip to the inside of the house Fig 181

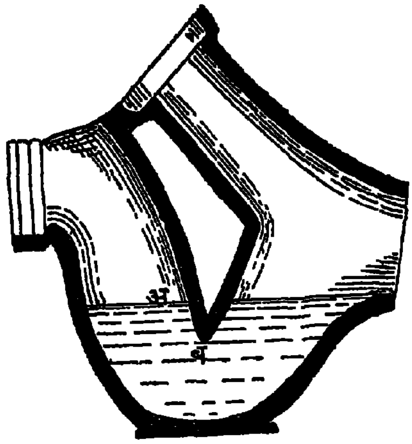


Fig. 182
Stoneware intercepting trap

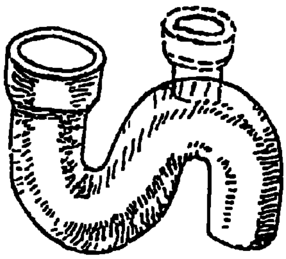


Fig. 183
Stone ware siphon trap

shows a gully trap which is required between the main drain and every sanitary fitting. Figs. 179 and 180 show a Nhani trap and 182, an intercepting trap, respectively.

House drainage is concerned with removing from the premises of a house as rapidly as possible (1) rain water and (2) waste water, whether from bath rooms, kitchens, sinks or latrines with a view to treat it suitably so as to render it harmless.

As regards rain water, it is comparatively easy, if the building occupies an elevation in the plot to drain it off and lead it away to join the street gutter or storm water underground drain, if provided by the local authority In the latter case it is necessary to provide a gully trap where it joins the public drain. As regards (2) three different classes of areas must be made, as each requires a different treatment. These are (a) Rural areas (b) Towns and Cities the sanitation of which is controlled by local authorities, but where hand removal of night soil from latrines is resorted to and (c) Cities in which water carriage system has been provided.

The first requisite common to all these classes is to exclude solids from the drains by providing suitable grating at the outlet of every sink. A *Nhani* trap should of course, be prefered to a simple grating and a pipe below.

(a) *Rural areas*:—Here some open space is usually available round the house, particularly on the back side.

Kitchen waste water :—There should be a suitable grating or preferably a *Nhani* trap fixed in the sink to exclude all solids including garbage; the drain pipe on the outside of the sink should be of 2 inch. diam. without either a bend or an elbow at end, and should discharge on the top of grass put into a vessel with perforated bottom, placed on the top of a cement lined pit about 6 in. deep. The grass, which should be renewed every day, will arrest all fatty matter and also the scum on the top of boiled rice and other finer solids and allow only the water to trickle through. A half round drain of 4″ stoneware pipes set in cement, of at least 10 ft. length, should lead the waste water to a soak pit about 10 ft. long, 2 ft. wide and 18″ deep filled with rubble, broken bricks gravel etc.. loosely filled.

Waste water from bath room :—A *Nhani* trap and a 2 inch. pipe should be fixed in the sink as above. The latter should discharge directly into a half round stoneware gutter to lead the water at least 15 ft. away from the house. If the space is sufficient it should be allowed to spread on as large a piece of ground as possible, on which some sort of crop, or even grass, should be grown. The practice, either of allowing the water to soak into the ground close to the house, or of leading it away into a pond or a pit for growing *aroidoe* plants (used as vegetable), or even plantains, should be stopped. Or, if a septic tank is constructed as described in the following chapter, the bath rooms should be built at the head or top of the drain, which, in that case, should be covered

and the sewage (including night soil) should be admitted to it and the whole discharge led to the septic tank for further disposal.

Effluent from latrines :—This subject is treated separately in the next chapter.

(b) *Towns or Cities under local authority* where no water carriage system has been provided for. If the space round or in the vicinity of the house be sufficient. the arrangements suggested for the rural areas may be adopted. If not an under-ground cistern plastered with cement may be constructed of sufficient capacity to accommodate all the waste water from the kitchen. sinks and bath rooms and all the open drains which should be of half round stoneware pipes set in cement should be lead to it and once in the course of the day the water should be lifted and distributed either to plants in the garden or if there is no garden, it should be spread on the surface of open ground.

The arrangement of separating fatty and other matter from the slop water from the kitchen by interposing a layer of grass is necessary even in this case.

Regarding the liquids from the latrine a pit should be built inside the covered chamber on the outside as suggested while describing a type latrine for such areas on page 262

(c) *Cities where water carriage system is available* :—A system of drains should be laid at a minimum depth of 6 inches below ground level with an adequate bed fall of 1 in 40 for 4 in. pipes and 1 in 100 for 6" pipes and all the fixtures such as sinks, bath tubs, lavatory basins, W. Cs.. etc should be connected to it at the nearest points on the following principles ·

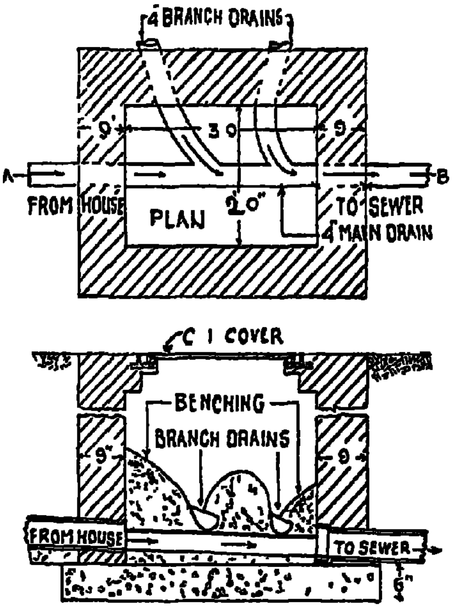
(1) All the drain lines shall be straight and shall be laid true to line and gradient, and jointed with tarred or

cemented gasket in one length, caulked and cement forced into it all round.

(2) No drain shall pass below a building

(3) Tributary or branch drains shall deliver sewage in the direction of the main flow either by a 'Y' junction or in an inspection chamber.

(4) An inspection chamber or a * manhole shall be built at every change of direction in the line and if the line is straight and long, at every 100 ft. or less of its distance. It should be sufficiently large to enable obstruction if any to be removed. Thus it should be 9″ x 12″ upto one ft. depth, 1′ x 1′-6″ for 1 to 2 ft. depth, 1′ -6″ x 2′ for 2 to 4′ depth, and 2′ x 3′ for larger depths. A typical inspection chamber is shown in figs. 184 and 185 in which two branch drains are shown to meet the main drain at an angle. Inside the chamber, curved open channels are formed and the space on their sides is sloped or "benched" up.



CROSS SECTION ON AB

Figs. 184 & 185
Plan & section of an Inspection chamber

(5) Each fixture such as a slop sink, urinal, water closet, bath tub, etc., shall be provided with a separate trap.

(6) The following shall be the minimum sizes of pipes : S. W. drain pipe 4″, Soil pipe for water closets 4″, slop sinks

*An inspection chamber and a manhole both mean the same thing A manhole is larger because it is deeper and is called a manhole as an opening for a man to get into it for inspection is provided

and rain water 3″; bath and laundry tubs 2″, urinals and wash basins $1\frac{1}{2}$″.

(7) All joints shall be made perfectly air and water-tight Joints between iron and S. W pipe shall be made with cement mortar, joints of lead pipes shall be solder wiped joints (See figs 186 and 187) those between lead and brass also wiped joint, those between lead and wrought iron pipes with heavy brass soldering ferrule screwed to iron pipes.

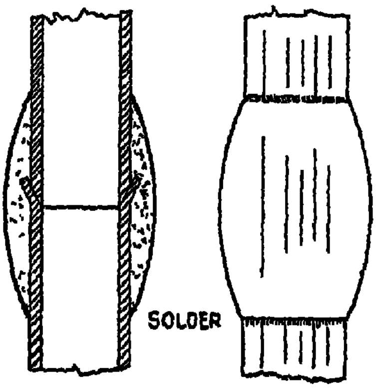


Fig. 186 & 187
Section & elevation of lead pipe wiped joint

(8) Every water closet shall be provided with a special 3-gallon cistern with a cover without holes, to prevent breeding of mosquitoes and shall be of a pull chain type with an overflow pipe discharging into the open See figs. 173 and 174.

(9) The main drain shall be ventilated in the following manner: At the tail end of the main house drain, *i.e.*, at

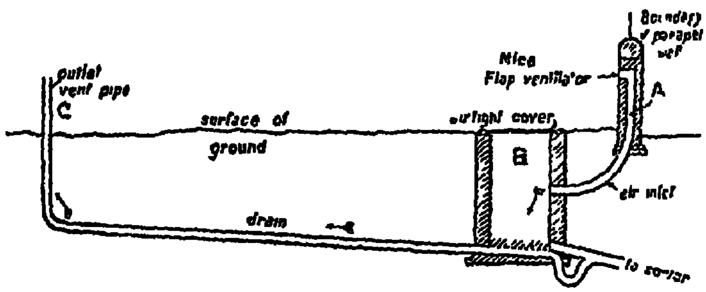


Fig 188
System of ventilation in house drain

its lowest end, shall be fixed an intercepting trap with

a plug in the upper end (See fig. 188) in a chamber, before the drain joins the street sewer. A hole in one of the walls of the chamber connected to a ventilating pipe carried a few feet above the ground provided with a mica flap valve in the inlet which allows fresh air in, but prevents foul gases from the sewer, by back pressure, will supply fresh air to the drain. Air being lighter will rise through the long drain to the top of the specially provided ventilating pipe and carried high above the roof at the head of the main drain as shown in fig. 188 in which at A is the vertical air inlet pipe with mica flap valve carried 3 or 4 ft. above the ground. The fresh air enters the drain through it, purifies the air and finally escapes through the vertical pipe outlet C carried above roof level. The intercepting trap is fixed at the end of the drain in chamber B.

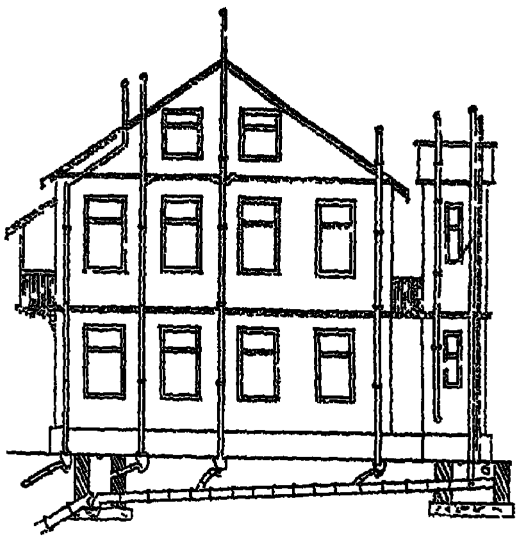


Fig. 189
A complete scheme of house drainage

Fig. 189 shows a complete scheme of house drainage embodying all the features mentioned above.

*DISPOSAL OF SEWAGE IN RURAL DISTRICTS

As compared with crowded towns and cities there is plenty of everything in rural districts—plenty of fresh air and sunshine, plenty of fresh vegetables and fruits full of vitamins, plenty of milk and eggs and also plenty of outdoor physical work. Thus a dweller in rural area is expected to possess more strength and vitality and immunity from diseases than the City dweller But what do we actually find? The life in villages is more uncertain due to the frequent ravages of epidemic diseases, mostly carried and spread by bacteria This is due to lack of sanitation, particularly in respect of the neglect of disposal of human and animal waste Cholera Typhoid, Dysentery and Hook-worm owe their origin entirely to intestinal waste matter, carelessly allowed to rot and dry in proximity of dwellings The germs of the first three diseases, *viz.*, Cholera, Typhoid, Disentery are actually swallowed either with food or water. Hundreds are the ways in which this is unwittingly done. For example, flies sit on the rotting filth and then settle on food with their feet full of dangerous bacteria. The germs may be carried to the sources of water supply either directly or by infiltration of sewage through soil saturated with it. The dry excreta might also be crushed under feet, blown by wind in the air and settle on the surface of food, bazar sweets, water or milk as dust and find a direct entrance to human intestines

The fourth disease, *viz.*, the hook-worm grows in the intestines of human beings and its eggs are thrown out in enormous numbers in excreta. One worm produces about nine thousand eggs per day

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* It was announced by the Author in the preface to his "Modern Ideal Homes for India" that he was shortly publishing a booklet on the "disposal of Domestic sewage and House refuse' But on account of the circumstances created by the War it was not possible This chapter is specially inserted here in rather greater detail to fulfil that promise

The worm develops into the larvæ stage in warm, damp earth. When persons walk barefooted on such a ground, the larvæ, which are picked up on the feet, enter through the skin into blood stream and are first carried to lungs, whence they break through into the air sacs, pass up into the throat and are swallowed. Thus they finally reach the intestine, where they develop into the worm stage. Sometimes, the larvæ are directly swallowed with green vegetables eaten raw. Though the disease is not fatal, it lowers the general vitality of the victim who then easily falls prey to other diseases like Malaria, Tuberculosis etc.

All these are preventable diseases and they can be prevented only by perfect sanitation, particularly in respect of disposing of excremental matter in such a way as to render it harmless. The requirements of an ideal system of sewage disposal are that,

(i) It should be cheap.

(ii) Its construction should be so simple as to be within the capacity of the village carpenter or mason to make or repair it.

(iii) It should not give access to flies.

(iv) It should not give out any foul odour.

(v) It should not cause any splashing or scattering of sewage over ground surface.

(vi) It should keep out dogs, pigs, rats, cows, buffaloes and other animals.

(vii) It should not contaminate the source of water supply such as streams, wells, etc.

(viii) It should require the least quantity of water, should this be necessary either for its cleaning, dilution or purification.

(ix) It should be automatic in action. No constant attention should be required for its maintenance.

(x) It should be fool-proof and if anything sometimes goes wrong at all, it should give a fair warning but should not cause immediate adverse effects

The condition (i) is self-evident in view of the abject poverty of the average Indian cultivator

(ii) The condition regarding simplicity of construction is obvious. There may be complicated installations constructed on strict scientific principles but if anything slightly goes wrong, an expert will have to be called for from cities

Regarding (iii) on account of the familiarity, the havoc played by the common house fly is not properly appreciated. Not only is it one of the dirtiest animals but it is no exaggeration to say that it is a messenger of Death. It is more fond of putrefied things such as fæces, blood, pus, etc., than clean sweats and dairy products A fly cannot eat solid substances such as sugar. It, therefore, liquefies such things by dropping its saliva on it and then swallows it to its heart's content. It is so voracious that when it cannot eat any more it vomits and empties its bowels on the food and when the latter is wetted starts eating it again. It has six legs each full of thick hair growth as shown in fig. 190 and there are two pads of hair, soft like velvet, at the bottom of each leg upon which it rests. Thus, when it sits on filth, innumerable particles of it are bound to stick to the pads and the hair, and when it settles on food in this condition, millions of disease germs are introduced into the food. Whenever filth is exposed in latrines there are invariably swarms of flies sitting on it and these when tired of feeding on it and want a change, enter the house directly and sit either on food in the kit-

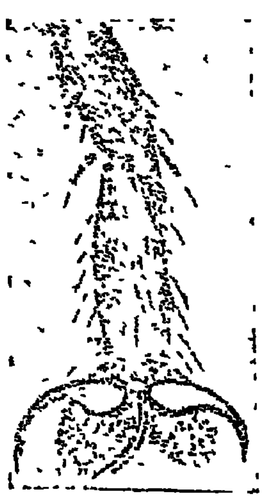


Fig. 190
Leg of a house fly (magnified)

chen or on the lips and eyes of infants. The germs left on the lips enter the mouth with the saliva and diseases like diarrhoea are produced, to which, very often the innocent babies succomb on account of their low vitality. That is why it is a messenger of Death.

(iv) Foul odours indicate that the system is not working properly

(v) If sewage is allowed to be splashed or to lie scattered about on the ground surface, the hook-worm is likely to spread and troubles from flies also will arise.

(vi) If dogs and other animals get a chance to eat the filth they are likely to spread the disease by contaminating food or water with the filth sticking to their mouths.

(vii) If sewage be allowed to soak into the ground, the sub-soil strata are soon saturated with it and if there be a well or a stream nearby, the liquid sewage passes in course of time, unfiltered and enters the wells or streams.

(viii) There is a great scarcity of water in a large number of Indian villages. In some of them water even for drinking has to be brought from long distances. Hence, the condition that the system of disposal should not require any water, and that if it cannot do without it, it should need a minimum quantity, is very important.

(ix) and (x) In view of the caste and social prejudices, that none except a person of the sweeper class should touch such disposal installation, it is necessary to lay down the condition that it should be automatic in action, and should require least attention for its maintenance

Let us now discuss the various systems and verify how far each one of them satisfies the above requirements · The various systems in vogue at present are : (1) Using open space

(2) Conservancy or basket system and hand removal (3) Water carriage or flushing system (4) Earth-closets (5) Bore-hole latrines (6) Trench latrines (7) Septic tank (8) Broad irrigation

(1) Using open space for answering the call of nature is the most primitive system It was not so objectionable when in primitive days houses were scattered Even then the aged, the sick and children used the premises of the house out of necessity. But gradually the grown up people in health also, on account of their slovenly habits, found it convenient to follow suit and this continued even though the houses were built close together. This has given rise to general insanitary conditions in and around villages with consequent spread of diseases. This system is most objectionable even from the point of view of privacy, particularly, amongst women folk. Lastly, the material which would have been very useful as manure for agriculture which is suffering for want of it, is converted into poison!

(2) *Conservancy or the basket system*:—This system has been tried for a long time and has been found to be equally bad, nay, even worse in some respects. In the first place, in the areas under local authorities more than 50% of the houses have no latrines of their own, and the public free latrines if provided at all, are too few to cope with the demand In consequence, conditions worse than the above prevail there. For, in villages there is at least ample space round the houses, but in towns it being very scarce streets are made use of, by young children, any time by day and by adults, during small hours of the morning or after dark. Even where latrines are built, the baskets usually overflow, the liquid sewage flows into open street gutters with swarms of flies breeding and feeding on them The latrines themselves are very insanitary with mud walls and mud floor, which is scarcely or never cleaned Often times no paving

either of concrete or flagstones is provided even below the basket. At some places, the basket is unserviceably broken or often altogether missing!

All this is very bad indeed, but there are still graver problems involved in it. Firstly, it is a mistake to leave the most vital question of our health to the mercy of the sweeper and to depend entirely on a class of people who do not know the value of sanitation. He does not care for the house owner and would not tolerate any remarks from him for unsatisfactory work. Very often he sets aside the orders of his superiors, makes unreasonable demands and if they be not fulfilled, goes on strike. How often do we hear of sweepers' strike and the sanitation of whole city thrown into ruinous condition?

Secondly, there is a social aspect to the problem. The sweeper is a human being, made of the same flesh and blood as we. Why should he then remain perpetually in bondage, do such filthy work and remain for his whole life "untouchable" and "unclean"? He has served us all these days, badly or well, but faithfully according to his lights. Instead of rewarding him for his services, with education we have condemned his whole class as untouchable. It is a shame to us, fellow human beings! It is only in India amongst the nations of the world that a large part of the human population—several million people are selfishly held in servitude to do the filthy work. It is a curse to India and the sooner it is removed the better.

Thirdly, howsoever efficiently the system of hand removal be organised, the nuisance of foul odour and flies, while cleaning latrines, emptying baskets and carrying the sewage in carts through streets and finally emptying the carts into trenches, cannot be avoided. It is impossible to main-

tain the whole system so scrupulously clean as to be absolutely harmless.

Lastly, one who has examined the municipal budget will tell how expensive it is to maintain the necessary establishment and equipment and still the result is disappointing

(3) *Water carriage or flushing system* :—This is the most satisfactory system so far known. But it requires a number of facilities for providing which, a great outlay of expenditure must be made. First of all there must be plenty of piped water supply under sufficient pressure. Then a network of underground sewers on sanitary lines must be built and thirdly the question of the disposal of the entire sewage must also be adequately solved. If there be sea or large river with flow even in the hot weather season, sufficient to dilute the sewage, it may be introduced there, away from human habitation. This is most economical, otherwise, additional large capital must be spent on pumping the sewage and distributing it for irrigation of crops or treating it suitably as to make it harmless

(4) *Earth-closets* :—This has been already treated in the previous chapter If the ablution water is excluded from the pit and the necessary quantity of dry earth and ashes is used regularly, an earth-closet gives the most satisfactory results The cost of building a new earth closet as shown in Figs. 167 & 168 would be about 120 Rs. and would give good service to a family of six souls for 2½ years. After this, a 6-inch layer of dry earth should be spread on the top below the boarding and kept for a month. By this time the night soil would be converted into excellent manure, which is just like sticky soft clay, absolutely free from odour, so much so. that if servants be hesitating to empty the pit, it is worth trying onself and demonstrating to them. The value of the manure has been appreciated by our people as it is popularly known as "*Sonkhat*".

i e., golden manure but the social and religious prejudices have so far come in the way of availing ourselves of its benefit. After emptying the pit the walls and bottom should be scrubbed cleaned and any repairs to plaster if necessary, made when the pit is again ready for use

If ablution is made in a separate sink in a corner as recommended, the water should be allowed to run into a pit about 2 ft deep filled loosely with rubble, brick bats, etc., with a layer of 6 of earth at top. It should not be allowed to run on the surface.

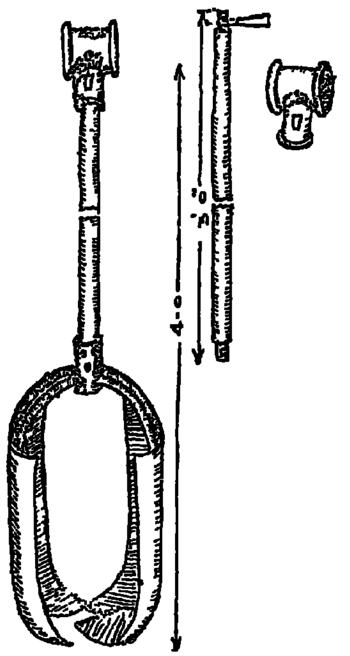
Next to the water carriage system, this is quite satisfactory and fulfills all the requirements and possesses one more advantage that it yields good manure of some value.

(5) *Bore-hole latrine*:—This is much cheaper and more convenient than the earth-closet but its chief requirement is, that there should be deep soil for the bore. Rock, murum, or even sand are of no use. The soil should be at least 4 ft. deep, if it is 10 to 15 ft. deep or more, it is an ideal condition. Heavy clay soil (not black cotton soil, which cracks) is the best Sub-soil water level even in the rainy season should be as low as possible

The site selected for the bore should be on an elevation and if such a site is not available one should be made artificially by filling earth and making the surface slope down on all sides as shown in fig. 194.

A hole of from 9 to 16 inches diameter is drilled vertically into the soil by an instrument of steel called an earth-auger. It consists of four fan shaped fins about 12 inches long with a vertical rod rivetted at the top, as shown

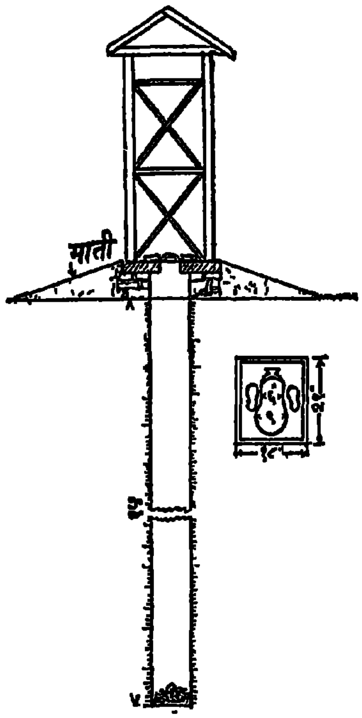
in Fig. 191. The total length of the auger is 4 ft but by means of a junction piece, rods 3 ft in length as shown in Fig 192 can be joined to it by means of a cotter pin and thus it can be lengthened to any extent First a small pit about a foot deep is excavated by a pick-axe and the auger held vertically in it and by inserting a wooden handle or a steel rod horizontally into the 'eye' at the top to apply leverage, it should be turned by two men going round and at the same time exerting some pressure on the instrument The instrument should be lifted from time to time and the earth core collected by the auger removed and the auger introduced again and rotated Incidentally this earth core serves to show the samples of the strata below. When about 2½ ft. depth is reached. a 3 ft lengthening rod should be connected and further work resumed. Four able bodied men are required for a bore-hole. While one pair is working the other takes rest. In this way 8 to 10 ft deep hole can be bored in one day.



Figs 191, 192 & 193
Earth auger & its parts

When the bore is completed a seat either of wood. stone or brick masonry. or specially moulded concrete as shown in Fig 195 with 7″ wide hole in the centre should be fixed for squatting and a small chamber with walls of bamboo

matting or coarse cloth, and a roof formed on top as shown in Fig. 195.



Figs 194 & 195
Section of a Bore-hole latrine and plan of the seat

Bore-hole latrine does not require earth and ashes to be sprinkled on the fæces, nor is it necessary to exclude ablution water from it. In these respects it is more convenient than an earth closet.

The cost of the auger together with extension rods is about Rs. 80/-. It can be purchased on a co-operative basis. For a family of 7 or 8 souls, a bore 15 ft. deep provides a capacity sufficient for one year.

When filled upto two ft. below the top, it should be completely filled with earth and a heavy stone kept on its top. After 2/3 months, the bore-hole should be emptied by the same instrument. This time the drilling is very easy and two men can do it in one day. The cost of a bore-hole including a rent of one rupee for the auger amounts to Rs. 5/- and the valuable manure is easily worth Rs. 10/-.

The bore-hole is automatic in action and if not used by more than 10 persons at a time does not give out any foul odour. Even though the sub-soil water rises, say, upto ¾th of its depth in the wet season, it gives satisfactory work. The only precaution required is, if it is infested with a kind of blue flies called "Blue Bottle" flies, as sometimes happens when the bore-hole is filled upto 2/3 ft., to put about 2 lbs. of fresh quick lime into the hole.

The bore-hole satisfies all the requirements of an ideal system except one, viz., it is likely to contaminate the supply from a well. It should not, therefore, be drilled within at least 30 ft. from a well and further, the same bore-hole. after it is once filled and emptied, should not be used again if it be near a well. but another should be drilled away from the first.

(6) *Trench latrine* :—This works on the principle of the earth-closet and in essential particulars does not differ from it. This is specially suited to Village Associations. For a village of 500 population a trench latrine of 10 seats is sufficient. The latrine should be arranged in two rows, one for

Fig 196

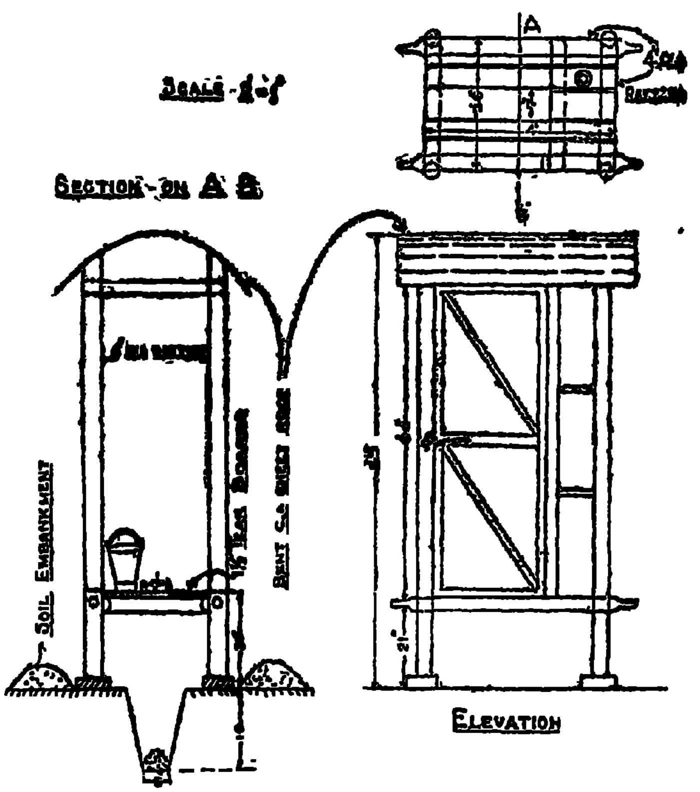


Fig. 197 Fig 198

Plan & section of a stretcher type portable trench latrine

men and the other for women. A trench not more than 4 ft. deep and 3 ft. wide at top and of length, at the rate 2′-9″

per seat should be excavated just outside the village away from the direction of the prevailing wind and either dry earth should be provided in kerosene oil empty tins open at top in each latrine for being spread by each user, or a special man should be appointed to do this.

An improvement over this can be made by building brick lined trenches and placing either portable or folding latrines on their top. There should be two sets so that while one is being used the other which is already filled is given some rest for the contents being converted into harmless manure. Use of clean waste papers should be encouraged by supplying them instead of water for ablution which requires more earth and makes the problem difficult.

For domestic use a portable trench latrine is very convenient. Figs. 196 to 198 show a suggestion of a cheap design which the writer suggested a few years ago and has since been adopted by several Village Uplift Associations and a large number of them have since been giving perfect satisfaction. The squatting platform (Fig. 196) consists of a frame, made like that of an ambulance stretcher but only half as long, with projecting handles, of two 4 ft. and two $2\frac{1}{2}$ ft. long pieces of wood. Upon these are nailed $1\frac{1}{2}''$ boards so as to leave a lengthwise gap 7″ wide and 2 ft. long in the centre. The platform should then be fixed between four vertical posts about 8′ long, at 2 ft. from the bottom. The frame thus formed should be enclosed either by bamboo matting or hessian cloth nailed on to it and on one side a door should be provided preferably with a self-closing spring. A suitable roof may be provided on the top.

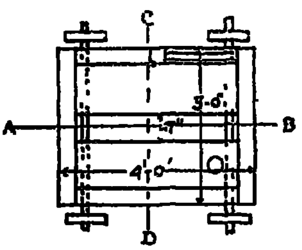
This portable latrine should be placed centrally above a trench 6″ wide at bottom and sloping sides, and with top 18 to 24 inches wide and of the same depth The earth ex-

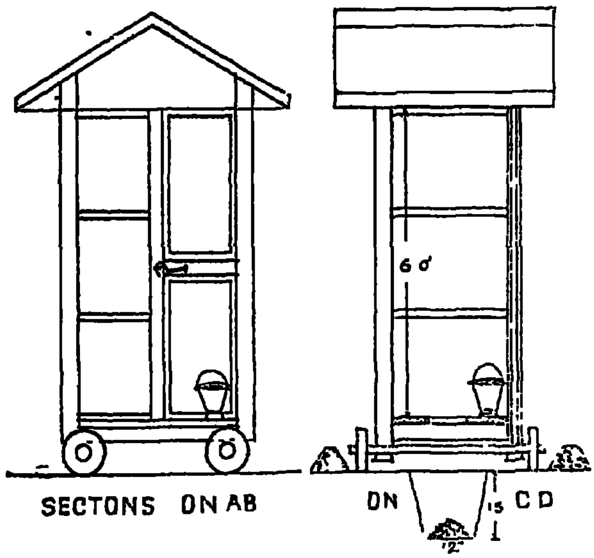
cavated from the trench should be heaped in long ridges on both sides to exclude surface flow of rain water

A bucket, full of ashes and dry earth mixed together with an iron scoop in it, should be kept inside the latrine The user of the latrine should spread the mixture with the scoop on the fæces so as to completely cover them

When the portion below the trench is nearly filled upto the ground surface, the portable latrine should be lifted by means of the handles and placed a few inches forward or backward and some earth from the side ridges drawn to fill the portion previously used

Fig 199





Figs 200 & 201
Plan & Section of a truck type portable trench latrine on wheels

A trench 10′ long would last for over 8 months for a family of six souls

Instead of a stretcher-like frame with posts resting on the ground if four wooden wheels with axles are fitted as shown in Fig 199 it would be easy to push the portable cart latrine without much effort A complete latrine which costs Rs. 11/- is shown in the photograph in Fig 202.

Precautions :—

(1) Choose a site, the wind from which will not blow towards the home to preclude the possibility of a nuisance, should anything go wrong at all

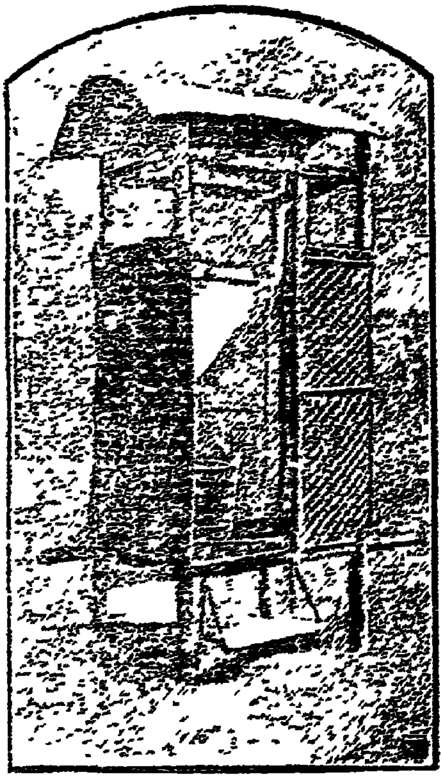


Fig. 202
Photographic view of a stretcher type trench costing Rs. 11/-

(2) The site should be as far away from a well as possible. As a further precuation. if a well is close by, the trench should not be more than a foot deep and more earth should be used. so that the sewage will not concentrate at one place and the chances of contamination of water would be reduced to a minimum.

(3) Proper precautions should be taken that rain-water will not enter the trench, at least will not form a pond on its top.

(4) Once a week crude oil should be sprayed by means of a 'Flit' or 'Poysha' pump over the trench and floor of the latrine to prevent flies sitting. If trouble from Blue Bottle flies is experienced, quick lime should be spread on top of the trench.

Advantages .—

(1) If the above precautions are taken and earth is regularly spread the system is most satisfactory.

(2) It affords the best privacy. Even the *purdah* ladies, children and sick people would find it convenient

(3) It is very cheap both in the first instance and also in maintenance.

(4) The construction is very simple, materials required for its upkeep, *viz.*, dry earth, ashes and crude oil are all handy. One gallon of crude oil costs five annas and will last for a year. There is nothing likely to go wrong.

(5) The capacity of an earth-closet is limited: that of this trench is unlimited, since the bed and sides are all absorbent and so, less earth is required than in an earth-closet There is no necessity of doing ablution in a separate sink

(6) As the latrine is moved from place to place the concentration of sewage is prevented and thus there is very little chance of contamination. The excreta are converted into harmless humus within 8 days.

(7) It is not necessary to empty the trench as in the case of the earth-closet or the bore-hole and still the benefit of the valuable manure is fully derived. since, whatever crops or vegetables are grown on or near the trench their roots will obtain the nourishment

(7) *Septic Tank* :—

There are two wrong notions, which are opposed to each other, prevalent among people about the Septic Tank There are some people who believe that a septic tank is a very complicated affair and that it requires a large quantity of water for purification and that if that is not available it is bound to be a failure. The other people, who are enthusiastic advocates, maintain that they have found a very cheap

and easy method of disposing of sewage Both are partially wrong and partially correct. Septic Tank is a very simple natural process and there is nothing complicated in it Domestic sewage is very simple and easy to treat as compared with sewage from a city which contains trade wastes, acids grease and many other things difficult to digest. and can be easily purified by the installation of a septic tank However. it costs a minimum of Rs 60/- exclusive of the cost of the latrine and does require some water for its proper working. However, if it is suitably designed it can function very satisfactorily even with a supply of one gallon per head per day. The supply can be supplemented if the waste from the bathroom is led to the septic tank.

What is a Septic Tank? It is a cistern either of masonry or concrete, built mostly underground filled with water and provided with a cover. The sewage including the solid excreta. is allowed to enter it at one end and after it undergoes certain chemical changes during the period it remains inside the tank. is allowed to escape from the opposite end.

The action of Septic Tank :—The word 'Septic' is derived from *sepio* to rot and the primary function of a septic tank is to allow the sewage to rot or putrefy Now. when a substance rots—take for instance, a mango, either raw or ripe, it first becomes soft and as time passes on, becomes still softer and softer, and if it be opened at this stage, the liquid formed in it flows out. This liquid stuff also rots and is, in course of time, reduced in quantity by the formation of gases which eascape, giving out bad odour, until finally a very small quantity of solid matter, mostly the rind and stone, remains out of the large and fairly heavy mango in the beginning Exactly the same thing happens of the solid contents of sewage inside a septic tank, which, on account of the very favourable artificial conditions. hastens the process.

This process of rotting or putrefying is caused by the growth of a sort of very minute germs, or bacteria, which very rapidly multiply and feed on the organic matter. These bacteria abhor air, the oxygen in which kills them. Hence, they are called "Anærobic" bacteria. Darkness, humidity and warmth which are all present in a septic tank, help their growth.

The septic tank does one more function besides that of *liquefaction* mentioned above. It is *precipitation* or *sedimentation*. The solid contents of sewage are composed of about 65% of mineral matter and 35% of organic matter The mineral matter not only consists of sand, dust, ashes, etc., which find their way to the drain leading to a septic tank, but various salts such as chlorides. sulphates, carbonates, phosphates, etc., which are consumed with food and which after undergoing a number of chemical changes inside our body, pass out. The anærobic bacteria have no action on these and so they remain in the sewage intact. The heavier particles of mineral matter sink down or precipitate to the bottom of the septic tank and the lighter ones float and ultimately pass out of the tank. Out of the 35% of the solid organic matter, the heavier particles temporarily sink to the bottom and lighter ones accumulate at the top in the form of "Scum." It is on these particles of organic matter that anærobes feed and breed. Thus this function of Precipitation is also very important.

The bacteria live both in the scum of organic matter floating at top and also in the particles of heavier organic matter precipitated at the bottom. They act upon and disintigrate it. The chemical action involved is very complicated, but the result is that complex compounds such as proteins, carbohydrates, fats, etc. are chemically split up into simpler elements such as carbon, hydrogen, oxygen and nitrogen. This process of splitting up is called "hydrolysis"

or "denitrification" in chemistry and liquefaction or putrefaction in common language. These simpler forms are either gases or liquid acids; the gases pass off through the ventilation and the liquids through the effluent, and thus, just as in the example of a mango discussed above, the bulk of the organic matter in the sewage, which otherwise would have formed large heaps, giving out offensive smell, is reduced by about 70 to 80% in volume in the septic tank through the agency of the anærobic bacteria.

The heavier particles of both the mineral as well as organic matter precipitate to the bottom. The mineral matter, on which the bacteria have no effect, accumulates and is known as the "Sludge." There is organic matter also in the sludge but the bacteria soon split it up into liquid and gases and continually reduce it. The sludge goes on accumulating year after year and progressively reduces the useful capacity of the septic tank, until a time comes when the incoming sewage does not get sufficient time, on account of the reduced capacity, to be properly digested by the anærobic bacteria and passes out in a raw state giving out foul odour. The time has then arrived of once emptying the tank. In the case of a scientifically built domestic septic tank, this might occur once in 10 to 12 years and the inconvenience caused is just for one day. The sludge is a dark liquid and gives no more offensive smell than waste water from kitchen or bath-room flowing into open gutters. The tank can be emptied either by buckets or a small hand pump in a few hours. It may then be washed and filled with water and reused from the next day.

It has been stated above that the quantity of organic matter present in the raw sewage is reduced by nearly 70 to 80% in the septic tank. This means that there is 20 to 30% of it still remaining in the effluent which passes out of the tank. Besides it contains a vast number of anæ-

robic bacteria floating on the surface and also a number of gases dissolved in it which are formed in the process of denitrification of the sewage. The latter are unstable. All these, if the effluent be left alone, would, not only give out foul odour but also prove positively harmful to health by contaminating food and water supply. The effluent must, therefore, be suitably treated and this treatment consists of bringing it into contact with fresh air, the oxygen in which combines with the unstable gases and converts them into harmless compounds like nitrates, carbonic acid gas, water, etc. This process of oxidation takes place through the agency of another set of bacteria, which live where there is free supply of air and are, therefore, called "*Aerobic*" bacteria.

There are a number of methods of utilizing the services of these bacteria to purify the effluent, but for treating domestic sewage the easiest and simplest ones are (1) surface irrigation and (2) soak pit. Both these particularly the soak pit requires very little attention.

For surface irrigation the soil must be of a porous nature, in the innumerable pores or voids of which, myriads of ærobic bacteria live and do their work silently. Light, sandy soil is the best. The soil which is most suited for plant growth is good also for this purpose.

If a piece of ground with such a soil is available on the back side of the house the effluent may be led to it through a half-round stoneware pipe drain and allowed to spread in furrows of loose soil. and vegetables may be grown on the top of ridges. As far as possible, leafy vegetables which are eaten raw should not be grown. Two plots should be made side by side and the effluent diverted to each alternately. The soil at surface should be mulched or loosened from time to time. In America excellent lawns are also grown.

For the second method also, *viz.*, soak pit, the sub-soil which is capable of absorbing or draining water is the best.

A pit of a size depending upon the porous nature of the sub-soil, should be excavated, say about 4 ft. deep and filled with stone-rubble having rough surface, over-burnt bricks, lumps of furnace or boiler slag, etc., very loosely in a layer of about 1′-6″ to 2′; above it should be spread a layer of gravel or unscreened sand and the top 9″ to 1 ft. should be filled with loose porous soil. The effluent should be led so as to flow on the top of the gravel or sand. Care should be taken to cover the drain suitably so that the earth at the top does not choke the drain. The voids in the loose material contain air and so ærobic bacteria make their abode on the rough surface of stones or brickes, or in the voids of gravel and do their work efficiently. If, instead of a pit, a trench is excavated it should be about 18″ wide at bottom, 4 ft. deep with sloping sides and 2′ to 3′ wide at top. If it be murum, laterite, sand, or such other very porous sub-soil, even 10′ to 15′ length will suffice. At the other extremity a 50 ft. length may be required in sticky clay material.

Surface irrigation does require some attention for diverting the flow to alternate plots and also for loosening the soil. But the soak pit is an automatic and fool-proof arrangement.

The writer has built a large number of such domestic septic tanks with soak pits with excellent results without a single failure.

From the foregoing discussion of the principles of a septic tank it will be seen that a good design should incorporate the following features :—

(1) The contents should remain as quiet as possible, *i.e.*, there should be no disturbance or churning action caused as the latter will dislodge the anærobic bacteria both from the scum and the sludge. This can be accomplished by (a) making the tank deep (b) arranging the openings of the inlet and outlet

pipe about mid-way and (c) providing one or more baffle walls or scum boards to damp waves caused by disturbance.

(2) The incoming sewage should remain as long as is conveniently possible, inside the septic tank. This could be arranged by (a) making the tank long and narrow, so as to increase the length of travel (b) providing a larger capacity consistent with economy

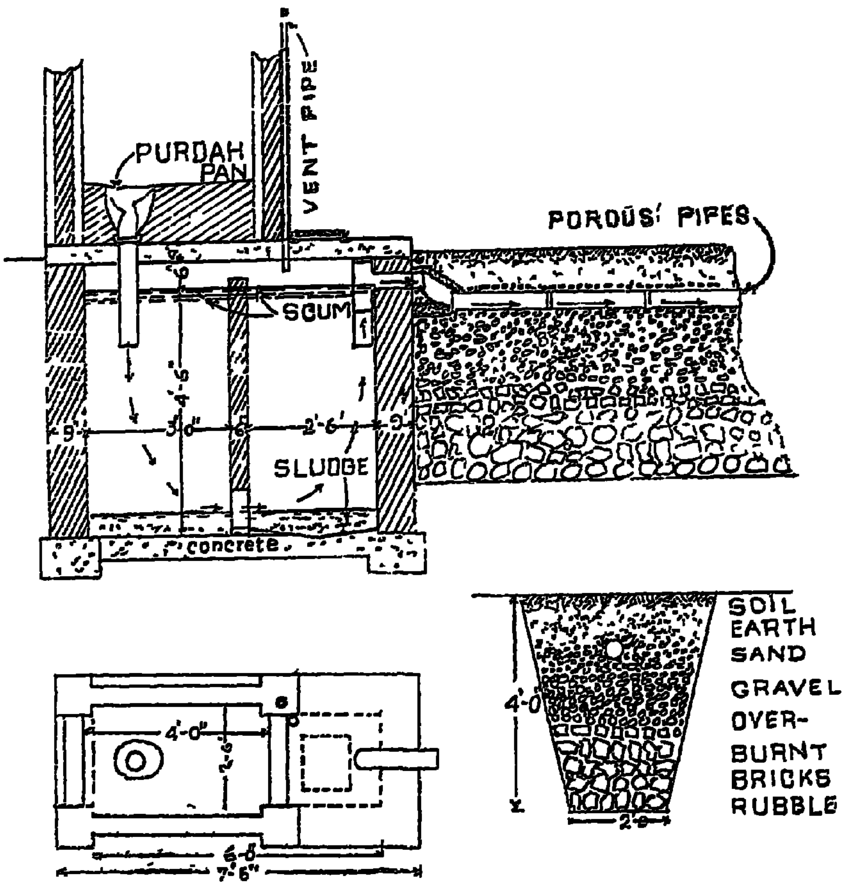
(3) The whole arrangement should be air and water-tight To attain this (a) the bed should be of at least of 6″ of concrete and sides of 9″ brick-in-lime masonry and both should be plastered smooth with cement. (b) There should be an air-tight cover—either of brick-jack-arches or R.C.C. slabs with an opening for inspection closed with cast iron cover at the top. (c) A ventilating pipe of at least one inch diameter should be provided and carried to such a height as would not cause any nuisance.

Three separate designs of septic tanks, each suitable for a family of members upto 12 in number, are given below.

Design No. 1*: This is the most economical design, and as it requires a very little quantity of water to maintain, it, it would be very suitable for areas where there is scarcity of water. In fact the water normally used for ablution, plus a bucketful poured every night for flushing and cleaning the floor and pan, should suffice. It is, however, advisable to take advantage of the water from a bath-room, after straining it through a suitable grating to exclude mineral matters such as sand, ashes, etc., and utilise it in the septic tank to dilute the sewage. For this the bath must be at a higher level than the septic tank.

* With acknowledgment to Ushagram School Colony, Ushagram, Asansol, Bengal from whose design the main idea is taken

The septic tank (See figs. 203 to 205) occupies an area of 7′-6″×4′-0″ including 9″ brick walls on all sides so that



Figs. 203, 204 & 205.
Plan & Sections.
Design of a cheap septic tank.

its inner capacity is 6′×2′-6″×5′ and has a reinforced concrete cover 4″ thick. The latrine is erected just on the top of a part of the septic tank. This has resulted in economy of foundations and one wall, drain and a trap below the pan. The pan is of a special kind called "Purdah Pan". It is white glazed on the inside and has two steep slopes on opposite sides as shown in fig. 203 which cause the excreta to slide down with very small quantity of water for flushing. Fig. 206 shows an enlarged view of the pan. A 4″ diameter stone-ware pipe 2 ft. long is joined vertically below the pan

and as it dips about 12″ in the water it forms a very good water seal. This dispenses with the necessity of a trap which is normally required. The outlet pipe consists of a 4″ diam Stone-ware T-junction pipe with its longer leg dipping completely into the water. The horizontal portion of the T-pipe is placed at 4′-6″ above the bottom, so that there is a 6″ air space above water surface. A ventilating pipe is inserted to project about three inches below the under surface of the R.C.C. cover. A partition of 4′-6″ bricks in cement mortar is provided with a number of holes in a horizontal layer at 6″ and 2′-6″ above the bed. This wall, which need not be plastered, is necessary to check the disturbance caused by the solid excreta dropping down vertically. A caste iron cover is provided on the top of the second chamber for facilities of inspection and emptying the tank when filled with sludge.

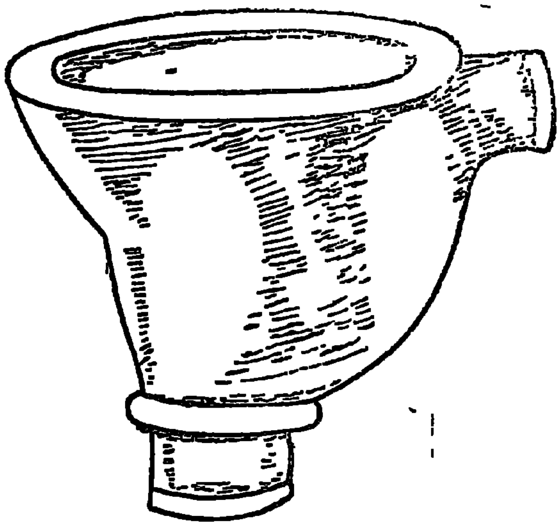


Fig 206.
Purdah Pan

The effluent is led through ordinary baked porous clay pipes with the smaller end simply inserted into the larger one and these rest on the top of a trench 2 ft. wide at bottom $3\frac{1}{2}$ ft. at top and 4 ft. deep (see fig. 205) filled with materials shown in the section. The total cost of this installation including the walls and roof of the latrine is about Rs. 100/-.

Design No. 2: This is a design suitable for an existing latrine which is built for the hand removal system, but is to

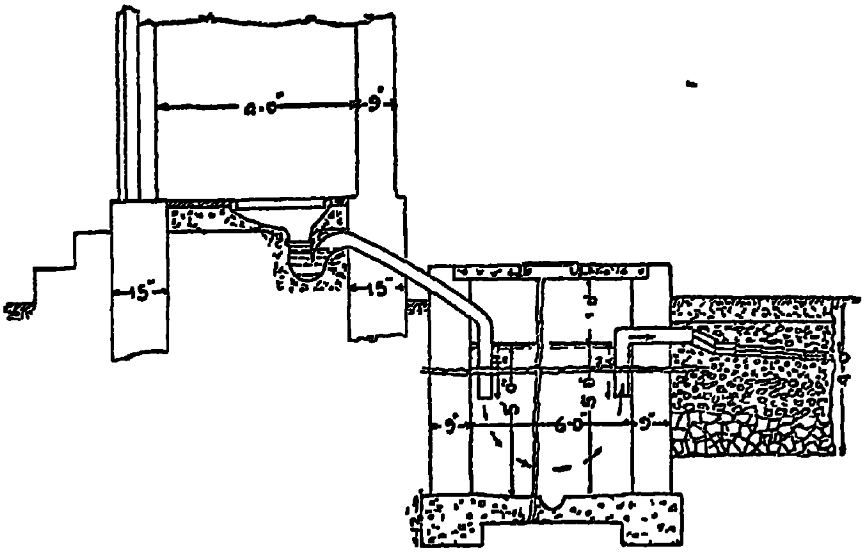


Fig 207.
A Design for converting an existing latrine on basket system into one suitable for a septic tank.

be converted into one suitable for a septic tank. See fig. 207. The space below the seat formerly occupied by the basket is filled with rubble or brick bats and a W. C. pan of the ordinary type with trap is fitted at top in concrete. Fig. 208 shows an enlarged view of the pan. A pipe connected to the trap is extended so as to dip about 2 ft. below the surface of water in the septic tank built close to the latrine. The septic tank is 6 ft. long, 1′-9″ wide and 5′ deep inside the walls. There is no necessity of a partition as in design No. 1. The outlet

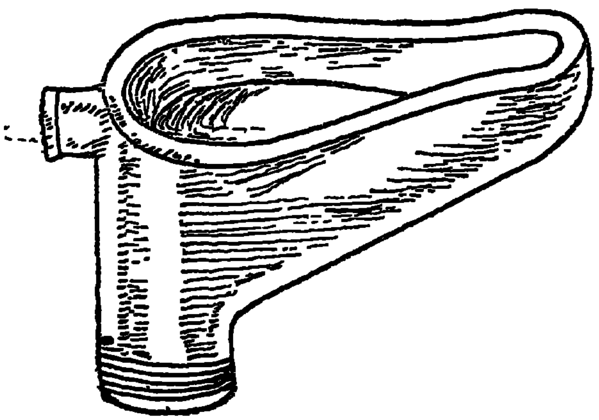
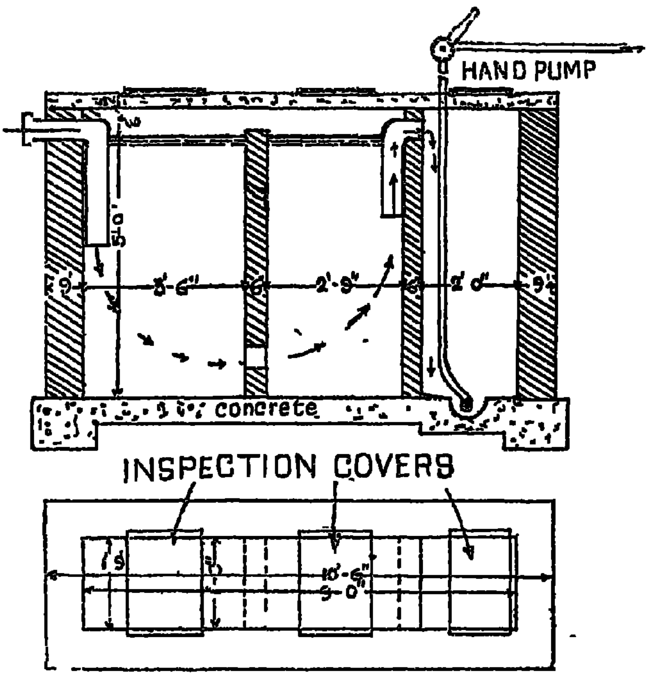


Fig 208
Indian Pattern W. C. pan

pipe should start from 2 ft. below the surface of water and should have either a T-junction pipe or an elbow joined to it at the top. The soak pit or soak trench should be similar to that for design No. 1. A pit or a depression about three inches deep should be made in the centre and a fall to the surface at bottom should be given towards it. An opening about 12″ × 18″ should be left in the cover at the top and closed by a cast iron manhole cover. It is desirable to provide a ventilating pipe, but septic tanks without it have caused no nuisance.

Design No. 3: This is rather expensive. The whole house is first provided with suitable drains with the drain from the bath-room at the top of the whole system, as laid down in the chapter on house drainage, so that all the waste water from kitchen, bath-room, and all other sinks is collected and led into the drain carrying sewage and finally admitted into the septic tank, which may be built on the back side of the bungalow away in a corner. The septic tank consists of two chambers, 3′-6″ and 2′-9″ long respectively, 1′-9″ wide and 5′-6″ deep as shown in fig. 209. The openings in the

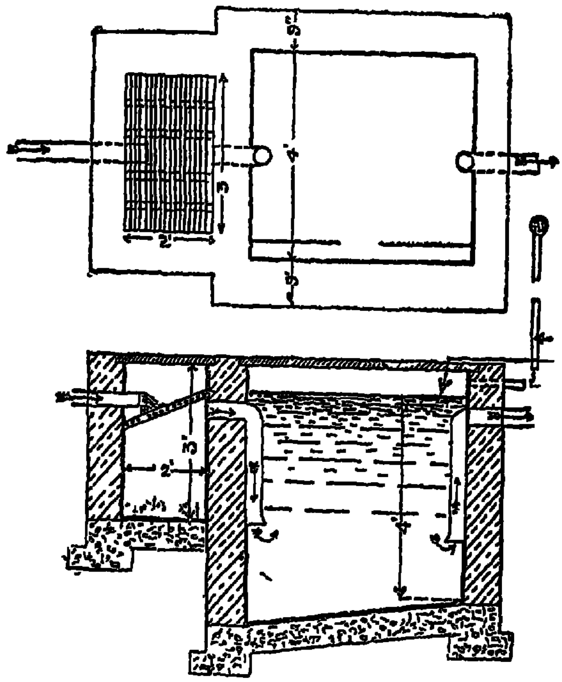


Figs 209 & 210
Section & plan of Design No. 3 of Septic Tank.

partition are left at two levels, *viz.*, at 6″ and 3′ above the bottom. There is a third chamber 2′ long in which the outlet pipe from the septic tank discharges the effluent. A sump is formed in the bottom of the latter in which the foot valve of a one-inch hand pump rests. The delivery pipe of the pump is connected to a perforated pipe laid on the surface of ground where a hedge is grown. At a certain fixed hour of the day the pump is worked for a few minutes and the effluent is forced through the perforations, so that it falls in fine spray near the roots of the hedge and being exposed to air is partially oxidised. It is further absorbed by the soil and assimilated by the roots of the hedge.

All the three chambers are provided with cast iron inspection covers.

When the entire drainage from a house is collected together for being treated in a septic tank it is quite necessary to provide one more chamber called *grit chamber* 2′ long x 1′-9″ x 3 ft. deep with a grating of iron rods as shown in figs. 211 and 212 which is an old design of a septic tank. This chamber serves three purposes: first, that all the silt such as ashes, sand, earth, brick-dust, etc., used for burnishing utensils falls through the grating and collects at the bottom of the



Figs 211 & 212
The grit chamber is shown on the left hand side with the grating in plan & section

grit chamber. This would, otherwise have entered the septic tank; the second, that shreds of paper, rags, loose coir, etc., used for burnishing utensils, which do not easily rot are arrested by the grating and excluded from the septic tank, and the third, that the solid excreta are also arrested by the grating and broken up by the jet of sewage which falls on their top and thus the work of the septic tank is simplified.

The following table gives the minimum inside sizes of septic tanks suitable for domestic purposes :-

Members of family including servants	Length	Width	Depth of Water	Cubic contents	Allowance per head
10	5'-6"	1'-6"	4'-6"	36.2	3.62
15	6'-0"	1'-6"	5'-6"	49.5	3.33
20	6'-0"	1'-9"	5'-6"	57.25	2.88
30	7'-6"	1'-9"	6'-0"	78.00	2.60

Upkeep of Septic Tank installation :-

(1) If there is scarcity of water and therefore design No. 1 is adopted, the bucketful of water used once at night for flushing and cleaning should not be poured all at once, but the floor and pan should be first cleaned with a brush and a little water and the bucket poured slowly to wash away the dirt. This precaution is necessary for preventing a churning action inside the tank.

(2) In the case of design No. 1 it is possible that the solid excreta might accumulate in the vertical pipe and choke it, causing bad smell also. The obstruction should be removed by pushing it down with a rod.

(3) As far as possible strong disinfectants or acids should not be used for cleaning sanitary wares and flushing drains. These kill the germs. However, if white glazed surfaces

are stained yellow a rag dipped in week muriatic acid may be rubbed against it occasionally.

(4) It is the custom in some houses to allow young children to answer the call of nature on a piece of paper and to throw the paper with the contents into a W. C. pan This is a very bad practice. particularly when the sewage is treated in a Septic Tank. Paper and rags take a very long time to rot; besides, they are likely to choke drains.

(5) If a ventilating pipe is not fixed on the top of a Septic Tank, it is possible that inflammable gases like the marsh gas (CH_4) might accumulate in the empty space below the cover. Hence. when the manhole cover is opened. a lighted cigarette or a candle should not be brought near it which might cause an explosion

(6) If only the water from latrines be admitted in the Septic Tank it is possible that the losses by evaporation might exceed the incoming quantity of liquids. This might cause the level to sink causing foul odour. to remedy this one or two buckets of water may be poured in the latrine

The same thing might happen if the latrine remains unused for some length of time. In such circumstances a bucketful of water should be poured once a week into it

DISPOSAL OF HORSE AND COW DUNG

The present practice is, in Municipal Areas, to throw the waste fodder and littre into Municipal dust bins and utilise the dung for preparing dung cakes for fuel. In non-municipal areas the littre is thrown in a muck-heap close to the house and the dung is used for preparing cakes for fuel. The latter is both insanitary and uneconomical. For, its manurial value is far more than that as a fuel.

The ideal way of treating the dung in rural areas is to store it in an underground chamber of masonry far removed from the house. The chamber should be lined with cement on the inside, with a water-tight roof above it. The door for throwing the dung inside should be self-closing. There should be another door normally closed, provided for removing manure and a ventilating pipe carried high in the air. This is, however, an expensive method. Hence, for people of ordinary means a pit, excavated in a distant corner with some sort of cheap roof—even thatch will do—to exclude rain, is recommended. To avoid the danger of the possibility of contamination of water in a well situated close by, the following precautions should be taken:—

(a) The contents of the pit should be kept as dry as possible by excluding liquids and by diverting surface water away from it.

(b) The pit should not be very deep.

(c) Ashes, dry earth and similar drying and deodorising agents should be occasionally spread in sufficient quantities in the pit.

(d) The pit should be emptied at short intervals.

(e) To keep off flies it should be covered with waste fodder on which crude oil should be sprayed from time

to time, especially in the beginning of the monsoon season, which is their breeding season.

Disposal of dry refuse:—

The first requisite for success in this matter is to train every member of the family including young children not to throw carelessly about, pieces of paper, peels and stones of fruit, shells of ground nuts, chewings of sugar cane, etc., not only inside the house, but even outside through windows. In fact, greater harm is likely to be caused by throwing such rubbish outside than inside. For the little scattered inside rooms, gets a chance of being swept and carried away once or twice a day, but that thrown out through windows, rots, breeds flies and does incalculable harm. Hence, a change in habits is the first essential. One who prevents dirt does a great deal more for the health of the family, than even one who cleans it.

The next measure is to provide suitable receptacles in a corner of every important room, with a cover, for collecting dry refuse. The bin in the kitchen should be of metal with plain surface on the inside with a tight lid. All the garbage from the kitchen should be wrapped in a paper and thrown into it. The metal bin in the kitchen should be washed with a strong disinfectant, every day.

All the receptacles should be emptied at least once a day into a Municipal dust bin. The contents should not be thrown away near it in its direction as is the usual practice. The usual sight in most Indian towns, for which both the Municipal Authorities and householders are responsible is that instead of the dust bin holding rubbish, the heap of the latter holds the dust-bin!

In Moffussil areas having no local authority, whatever is capable of rotting should be put into the manure pit and covered with ashes and dry earth, and whatever is capable of drying easily, should be burnt in a pit away from the house.

BUYING A READY-BUILT HOUSE

The merits and demerits of buying a ready-built house, whether new or old, have been already discussed in the beginning of this volume. It is proposed to discuss here a few technical points which a layman should investigate before he decides to strike a bargain.

(1) The first is about determining the age of the house. If inquiries show that it was built recently within the past ten years or so, the timber used for rafters, beams, postplates, etc., should not show any deflection or bending, if the construction be sound. A house, built about fifty or more years ago, can be easily distinguished by observing the following details :

(a) In those old days, timber was cheap and the tendency was to use oversize parts. Thus the posts, even those supporting a verandah-roof used to be at least $6'' \times 6''$. At present they are $4''$ square or at the most $4\frac{1}{2}''$ square. Further, it was then the custom to use joists or beams with the larger dimension as width. For instance, a joist of $4'' \times 2''$ and beam of $12'' \times 7''$ had $4''$ and $12''$ as their widths and $2'' \times 7''$ as the depths when used in position. At present they are laid with $4''$ and $12''$ respectively as the depths.

(b) In old times wooden posts were placed on stone chairs, now they rest on the floor, either of concrete or of stone slabs.

(c) In old times very little steel was used. In some situations copper was used. Now steel predominates very much and copper is rarely used.

(d) In those times the plinth usually consisted of three courses of finely dressed stones, with iron or brass

rings projecting through a brass or iron staple built into the masonry. In present times they may be of several courses and the face stones are not necessarily finely dressed. Sometimes the masonry is of uncoursed rubble type.

(e) The walls of such old houses, particularly those on the outside, bearing the ridge, were from 2′-6″ to 6′ thick and were mostly of stone in mud. In buildings of recent construction the width usually does not exceed 18″.

The age of the building is an important consideration in arriving at its present value by making a suitable allowance for its depreciation.

(2) The next point is to examine the walls near the plinth level. They should not show any damp. Damp is bad both from the point of view of health as well as that of deterioration of the structure. For instance, wood exposed to damp, rots, iron rusts, even brick wears out. It is very difficult and expensive to eradicate damp completely.

(3) Examine the walls first from a distance from the bottom to the top to verify if they are in a plumb line. If a doubt is felt, a plumb line should be applied to test it. If a wall is one inch out in a 12 ft. height it is a bad sign and if 2″ or more there is a positive danger.

(4) Tap all the wood work such as posts, post plates, beams, etc., lightly with a hammer or even with a finger at several places. If it sounds hollow it is affected by dry rot.

(5) Examine the top surface of the roof, first, from a distance, if the slopes are uneven or wavy or if the ridge is not straight, the wood work is bent or the workmanship is bad. However, in either case there are chances of leakage through it. Then examine the walls from the inside near

the top where the roof rests on them. If there are any stains in the distempered or white-washed surface, even if dry, they betray a leak. A leakage on or near the top of walls is a dangerous thing in walls built with wooden frames.

(6) Carefully search the surface of walls to see if vertical cracks, even though very minute, can be traced. If they extend over considerable lengths and particularly go through arches or lintels over the top of doors or windows it is a matter for serious consideration. If the walls have gone out of the plumb as a result of the cracks, it is a sure indication that the foundations have unevenly settled.

(7) The wooden staircase should not squeak under the feet.

(8) Terraced roof should be examined, first, from below for any stains or disfiguring of the ceiling, then the top for hair cracks. A leaky terrace roof is a source of unending trouble.

(9) The drainage system should be examined in respect of the requirements given in the chapter on house drainage, particularly to see that proper traps, inspection chambers and ventilating pipes have been provided. Drains which are likely to choke, off and on, are a source of danger to health. Hence, one or two buckets of water should be emptied either in the bath room or W. C. at the head of the system to see if it flows down rapidly to the end of the system without obstructions.

(10) If the source of water supply be a well, examine its water by applying potassium permanganate test. If water tastes brackish, it may be due to either mineral salts in the underground strata through which it is flowing or to sewage pollution. The above test will give some indication and if the results cause a suspicion, either the offer should be rejected or if other points are favourable, samples may be sent to a chemical analyser or better still to a bacteriologist.

EARTHQUAKE-PROOF HOUSES

It is common experience of persons travelling in railway, tram or a motor, that if the vehicle starts suddenly from a state of rest, we are thrown behind. This happens because our tendency is to sit erect, while the seat is suddenly drawn forward. The same thing happens to buildings during earthquakes. The building has a tendency to remain in the original position due to its inertia and the ground underneath moves all of a sudden. To continue the analogy further, since our limbs are joined together by means of bones and muscles, when the train moves forward with a jerk, our body first leans backward and the first reaction on our part is to take support by hands to avoid a fall. In the case of ordinary buildings, the walls are made by simply piling stones or bricks one upon another in mortar. They lack the core corresponding to the bones and muscles in human body, and therefore, as soon as the foundations are pulled laterally, the wall collapses even before it is tilted.

It will, therefore, be seen that the most important destructive force to be resisted in earthquakes is the horizontal motion of the earth's surface which may be either in one direction or vibratory, *i.e.*, in both directions and to counteract this some sort of core must be provided from the foundation to the top; this would make the wall, one, unbroken piece which might tilt on one side and fall, but not shatter into loose pieces. Further, if all the walls—both outer and inner including partitions, provided with such cores were tied down to each other at bottom, top and at several places midway, it would form a self-supporting structure, so that if one of the walls has a tendency to tilt the other walls would support it.

This is exactly what is required to be done in earthquake-proof buildings. Steel and reinforced concrete are the only

materials, found so far, suitable for the purpose.

In the case of the steel structure it is made of posts and beams of rolled steel joists rivetted to each other as shown

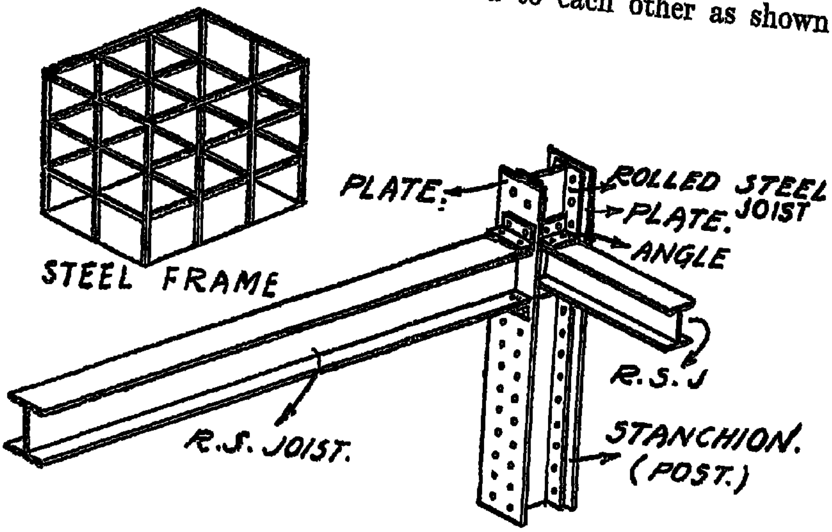


Fig. 213 & 214

Fig. 213 shows a skeleton of a Steel Frame Structure. Fig 214 shows an enlarged view of a joint showing how the vertical & horizontal members of the frame are rivetted together

in figs. 213 and 214 from foundations to the top and these are subsequently encased with cement concrete to prevent rusting. The gaps between the vertical posts are filled with brick, stone or concrete walls.

Reinforced concrete provides a more suitable material than steel, since it is monolithic, *i.e.*, without joints, more economical and better fire-resistant. The latter quality is of no less importance since very frequently fire follows an earthquake and its ravages are often greater than those of the quake itself. Reinforced concrete-framed building is made in two ways. In (1) vertical columns are erected on suitable footings and these are braced or connected together by beams, first at the plinth or basement level, if there be a basement floor, and then at floor level of each storey, and at top if there be a flat roof. Fig. 215 shows a perspective view of a section of a four-storyed building of this type. Wide foot-

ings are provided below each column similar to those seen in the front row, and walls either of brick or stone are con-

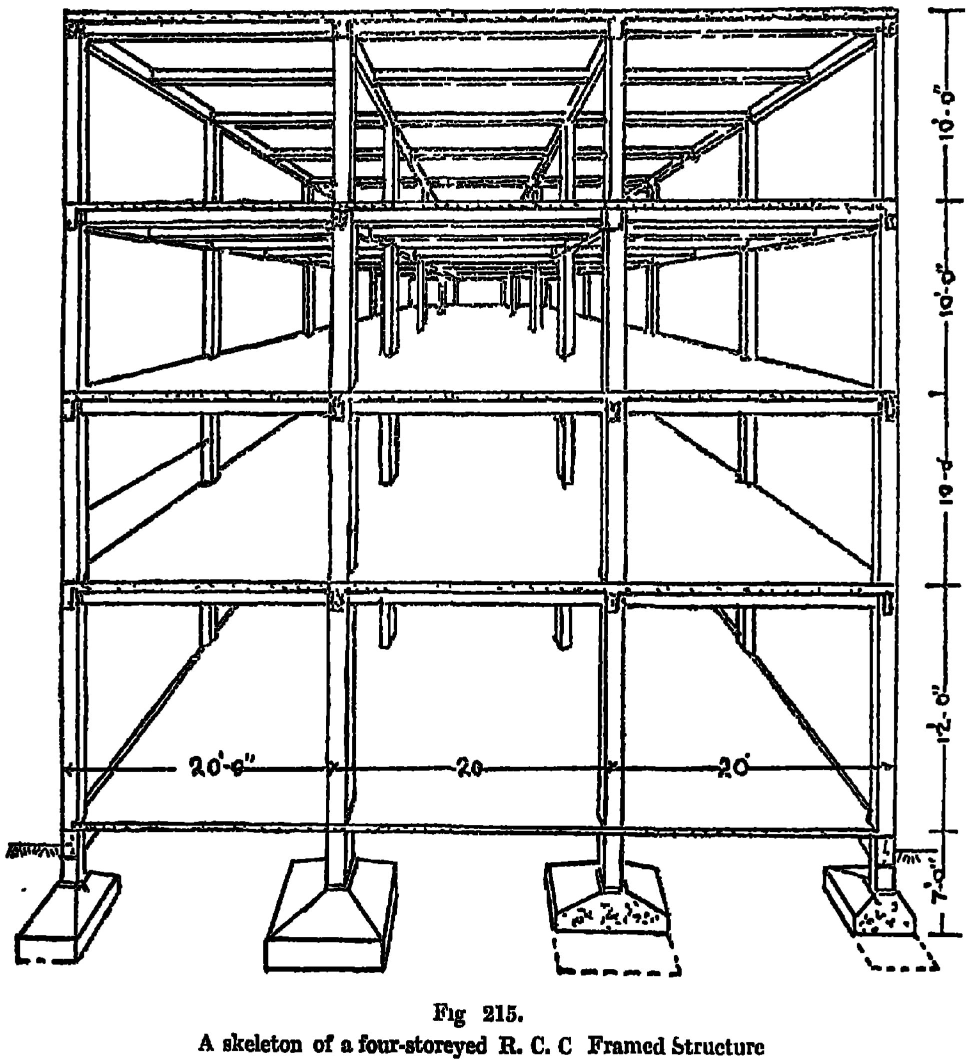


Fig 215.
A skeleton of a four-storeyed R. C. C Framed Structure

structed between the columns. These walls do not bear any load beyond that of their own. In the other type, monolithic concrete walls 8" to 12" thick with vertical and horizontal steel reinforcement near both the faces are constructed These walls act both as very deep and stiff beams as well as pillars. The floors which are also monolithic, *i.e.*, cast in one piece with the walls, serve as horizontal girders and make the whole structure very rigid.

The actual design is a very complicated matter and the reader is advised to consult an engineer in that respect. The general principles involved are stated below :

(1) The main idea is to tie all the parts of the structure so firmly together and so stiffly brace them that the whole building will tend to behave as one unit. Cross walls including end walls and floors should be tied to each other and all these to the long walls; openings for windows and doors should be away from the corners, leaving a pillar of at least four feet width near the corner.

(2) The minimum size of the intermediate tie beams connecting footings of pillars should be $12'' \times 12''$ with a minimum reinforcement of four $\frac{5}{8}$-in. longitudinal bars and $\frac{1}{4}''$ round hoops spaced not more than $12''$ apart.

(3) As far as possible symmetry in arrangements, both of rooms themselves and the windows and doors in the walls, should be sought in the design to produce equal deflections.

(4) If the height of the building is uniform throughout and the shape approaching a square, the design is simplified and the stresses are equalised with respect to the axis of symmetry.

(5) Buildings on hard foundations like rock are less affected by earthquake movements than those in clay.

(6) Extra reinforcement should be provided preferably diagonally round openings in floor slabs such as for staircases, lifts, etc.

(7) It is a mistake to build staircases so as to act as diagonal bracing between the floors they connect. Experience shows that such stairways suffer damage.

Hence, either an open vertical sliding joint may be provided at the place where it abuts against the upper floor or, if it is cast monolithic with the floors, it should be relieved of the horizontal thrust by rigid partition walls at the stair opening.

(8) Adjacent buildings of varying heights or dissimilar in mass or rigidity, should be separated by a space sufficient to prevent them from pounding one another due to different amplitudes of vibrations, during an earthquake.

HOMES AND AIR-RAIDS.

There are two aspects of the question, *viz.*, (1) Building new homes so as to include all the protective measures against air-raids; and (2) to make the necessary alterations in the existing homes for that purpose. Let us discuss (1) first.

It is needless to stress the necessity of including in the original design the construction of an air-raid shelter as a standard feature in all future buildings to be erected, both for residential and non-residential purposes. This would not only save a good lot of money and afford better protection with less cost, but would be an asset and a sort of insurance against risks. Further, it would serve as an additional accommodation, during peace time as a cool place in summer, or a hobby shop or at least as a basement store or lumber room.

An ideal shelter must give protection from (a) direct hit of a high explosive bomb (b) blast and splinters (c) poison gas (d) incendiary bomb (e) damp and flooding caused either by rain water or a bursting water main and (f) debris of a falling house or demolition.

To build the whole house in such a way as to make it proof against all these, particularly against a direct hit of a bomb is prohibitively expensive. Nor is it necessary. For, the chances are so few that they may be safely disregarded. In the first place, 500-lb. and heavier high explosive bombs are very expensive and a bomber plane can obviously take very few of them, because of limitations of speed, weight and cruising distance. The enemy cannot, therefore, afford to waste them on civilian population. Secondly, if it be the intention of the enemy to terrorize civilian population, he can do it better by using a larger number of 50-lb. or 100-lb. bombs than only a few of the heavier type of the same or even less aggregate weight. Thirdly, it is very likely that

high explosive bombs dropped from great heights might fall in open spaces like roads, gardens, play grounds, parks, etc., rather than on houses, since the latter occupy a very small percentage area as compared with that of the former. On the other hand, incendiary bombs are usually very small and weigh only about 2 lbs., and so even two thousand or more of them could be easily carried by an average bomber and a very large number of them may fall on top of houses It is, therefore, the best policy to (1) build houses just sufficiently strong to effectively resist the action of incendiary bombs and of blast and splinters only, caused by high explosive bombs exploding at a distance of 50 ft. from the house, and adopt such a construction that they will suffer the minimum damage under a direct hit, and (2) build a strong shelter, inside or below the house, of a size to provide sitting or standing accommodation for all the members of the family for the short duration of the actual raid. which would protect them from all the dangers including collapse of the house on the top of the shelter and also from poison gas. This arrangement would cost the least and still insure against all emergencies.

The principles underlying the design and construction of a house to fulfill the above requirements are:

(*a*) The structure should consist of frames with panel or filler walls between. The parts of the frame should be rigidly tied to each other and preferably cast monolithic. R. C. C. framed structure satisfies these conditions better and so it is preferable even to steel rivetted, or steel-welded frames. This clearly shows that a structure designed to withstand an earthquake is admirably suited also to A. R. P. The panels should also be of R. C. C. thinner section.

(*b*) If the house be built of solid load bearing walls of R. C. C., the reinforcement in walls should be of

thinner bars more closely spaced, than of thicker bars wider apart. It should be at two places about ½ inch inside from the faces.

(*c*) Whether in the case of frames or load-bearing walls, the floor slabs should be of R. C. C. They should form an integral part of the frames to which the reinforcement should be tied and the whole thing cast monolithic. The reinforcement in slabs should also consist of thinner bars closely spaced and laid in three directions, *viz.*, lengthwise, cross-wise and diagonal.

(*d*) The staircase should be of R. C. C. cast monolithic and tied with reinforcement to slabs.

(*e*) The roof should consist of solid R. C. C. slab 4″ to 6″ thick and should be made stronger by reducing the unsupported span by providing intermediate beams.

(*f*) The panes of windows should be of wired glass, which does not fly out into slinters.

(*g*) All the architectural features such as cornices, string-courses, copings, etc., which project or overhang should not be of loose material like stone or brick laid in mortar, but of steel reinforced concrete.

(*h*) In addition to the above precautions which will render the house efficient against fire, blast, splinters and total collapse, a shelter of a suitable size should be built preferably in the basement floor to give protection from gas, fire and the effects of explosion of a high explosive bomb near the house and as far as possible even from direct hit.

*Fig. 216. shows a shelter which is rather costly as it is designed to withstand even a direct hit. It is built along the inner side of an outer wall. As it has a massive top, it will stand firm even if the house collapses on its top by a direct hit. As its floor is at about 12 ft. below the ground and the sides are well-protected, it is also strong against a hit by its side. A suitable entrance with a staircase from the ground floor inside the house for rapid access and an infallible emergency exit with an inclined ramp or flight of stairs, well-protected, are necessary. The narrow width of 6 ft. and the massive arch at top, make the shelter very strong. If larger accommodation is required the length should be increased.

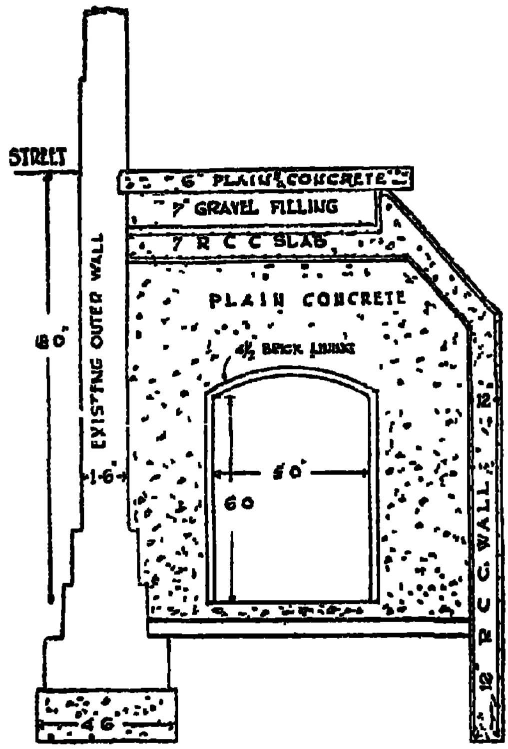


Fig. 216
An underground shelter inside a house.

If such a strong shelter, proof even against a direct hit is not required, an economical one may be built on the following principles :—

Position : A shelter below ground level is obviously the best because of the side protection thus secured. If there be a courtyard in the middle of the building, open to sky, a shelter along its side in the form of a

* Acknowledgement is due to Indian Concrete Journal, from the first Special A. R. P. number of which figs. 216 and 220 are taken.

cellar would be very suitable as it could derive light and ventiliation from inside the courtyard. It should not, however, be below large water tanks, heavy machinery, steel safe, etc. If either on account of rock or underground water trouble, a basement shelter is found very expensive or unsuitable, one may be built on the ground floor.

Entrance: This should be from inside the house near a staircase which should be easily and quickly accessible from all the rooms. The outer walls should be in cement mortar and if of stone, 21″ thick, if of brick, 18″, if of mass concrete, 15″ and if of R.C.C., 12″.

For a shelter under a building of ordinary stone or brick walls the following table gives the thickness of roof slabs and reinforcement with its spacing for different spans. The reinforcement should be *in both directions* at right angles to each other.

Span 6 ft.		Span 8ft		Span 10 ft.		Span 12 ft.	
Thickness of slab	Diam. & spacing of bars.	Thickness of slab	Diam. & spacing of bars.	Thickness of slab	Diam. & spacing of bars.	Thickness of slab.	Diam & spacing of bars.
6″	$\frac{3}{8}''$ at $3\frac{1}{2}''$	7″	$\frac{1}{2}''$ at 4″	8″	$\frac{1}{2}''$ at 3″	10″	$\frac{5}{8}''$ at 4″

The shape of the shelter should be long and narrow as a reduced span makes the roof stronger. With 15″ wide benches on both sides and 2 ft. leg room between them, a minimum width of 4′-6″ is required. However, it may be increased to 10 or 12 ft. at the most. An R. C. C. arch at top, obviously makes the roof stronger than a flat slab.

The height of the shelter should be 6 to $6\frac{1}{2}$ ft. at springing and 7 to $7\frac{1}{2}$ at the centre of the arch. The length may be increased to any extent.

If gas also is to be excluded the shelter may be sealed and ventilation effected either through a duct or a pipe carried 30 ft. high for supplying air. at which level the air is supposed to be free from the gas or a gas filtration plant including a fan should be installed In either case an air lock. consisting of a small closed lobby at entrance with close-fitting spring doors in opposite walls is required. When one door is opened either for admission or exit the other should remain closed.

All this is very costly. So families of slender means should allow ventilation through windows on the sides not exposed to splinters and rely on individual gas masks

The experience of the past three years of deadly war indicates that the possibility of using gas as a weapon against civilian population is very meagre. Further. the heat and consequent dryness of air and breeze in the tropical climate of India are sure to render gas ineffective.

The size of the shelter, that is the floor space per person depends upon the ventilation provided. It is not the exhaustion of oxygen from the air inside a shelter, but the rise in temperature and increase in humidity and the organic matter given out as a result of respiration which cause a feeling of oppressiveness. Hence. the surface area, *i.e.*, the sum of surface areas of the floor, ceiling and sides, is more important than the floor space. The following is the minimum proportion recommended by authorities in A R.P.

1. Gas proof shelter ventilated	...	7.5 sq. ft. of floor area per adult.
2. Unventilated shelter ...	.	75 sq. ft. of total surface per adult.

Children below 10 may be taken as ½ adult.

According to this scale the shelter of the first sort for a family of five adults should have 37.5 sq. ft. of floor area or having a size of 6′-4″ × 6′ or 8′-3″ × 4′-6″, and the one of the 2nd sort should have a total surface area of 375 sq. ft. which could be made by a shelter 11′ long, 6′ wide and 7′-3″ mean height.

In places where basement shelters are not possible, they may be built on the ground floor. In respect of an entrance, emergency exit, shape, size, etc., the same considerations as those for basement shelters are applicable to these. The roof, however, should be a little thicker than that of ordinary floor slabs. The thickness given in the above table for spans from 6 to 12 will be enough. The outside walls should be of sufficient thickness to be splinter-proof, *i.e.*, of plain concrete 15″, R.C.C. 12″ and brick in lime 14″. The inner walls facing the house need not be so thick. The entrance should be at such a place as will make it rapidly and easily accessible from any room of the house. If gas-proofing is not required, one or two windows may be provided in the exposed wall for light and ventilation in normal times. In war time they may be either closed with a steel plate $\frac{3}{8}''$ thick on the outside of shutters, or baffle walls either of sand bags 30″ thick or of brick 14″ thick may be erected in front of them.

A. R. P. in existing houses

Protection against blast and splinters. Any part of the house which is out of the plumb should be dismantled and put right, or, should be at least securely supported by means of timber struts

Glass panes of glazed doors and windows, the shutters of which open on the outside, should be removed and those of the shutters which open inside or of doors and windows in all inner walls, should be protected by pasting on them with a

strong glue, thin cloth or tough paper to prevent them from flying into splinters by blast and injuring persons inside

Protection against incendiary bombs .

No inflammable material should be stored on attic floors or lofts below the roof.

Roof timbers should be coated with a fire-proofing solution or paint

Small sand bags capable of being easily lifted and thrown on the top of an incendiary bomb for smothering the latter tools for lifting and putting the bomb aside for allowing it to burn itself and a stirrup pump with a suitable length of a hose pipe should be kept handy for use. Concrete or masonry cisterns should also be built and kept filled with water for fire extinguishing purposes since the public water supply may fail in times of need.

In addition to these precautions for minimising the risk, it is necessary to provide shelters for the safety of the inmates on the following principles.

(1) *Location* : If there be a cellar in whatever condition it should be improved and strengthened. as it is the safest place. Failing this a room or a corner on the ground-floor which could be converted into a refuge room should be selected. and if this also be not possible. or very expensive on account of the flimsy nature of the building. a shelter should be built on the outside. alongside an outer wall partially or wholly underground and if this also be not feasible, a covered trench shelter in the garden. away from the house at a distance, at least equal to the height of the house should be built

(2) The shelter should be blast and splinter-proof and should have a strong roof which will not collapse

even if part of the house falls on it. It should have, besides, an entrance from the inside easily accessible from any of the rooms at all times, and a well-protected, never failing, emergency exit on the outside

(3) If gas-proofing of the shelter is desired it should be done on the principles already discussed by sealing the shelter and providing an air lock and also ventilation either through a vertical duct 30 ft. high or through a gas filter by means of a mechanical fan

A few suggestions are given below for such shelters:

Fig. 217 shows a plan of a basement shelter. There is on the right hand side a staircase and in front of it is an air lock consisting of a small square enclosed lobby with close fitting doors at opposite ends. As the walls of the basement were not strong enough they are further strengthened by constructing 9 inch. brick in cement walls on two sides. On the left hand side, an opening is made which leads to a trench. The sides of the trench are lined with brick work and at the end of it is a ladder for emergency exit. The trench is protected by means of sand bags.

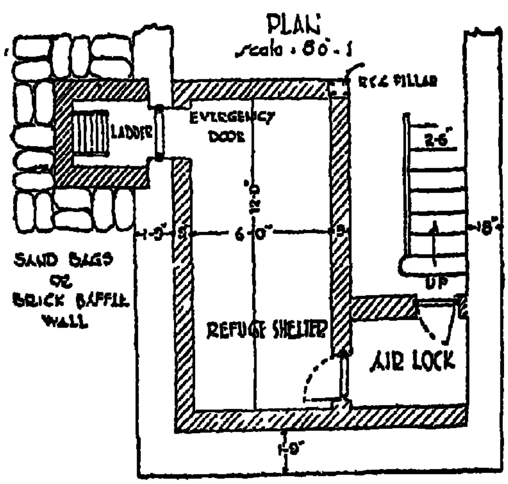


Fig. 217

Plan of a Basement Gas-proof shelter The hatched walls on the inside are 9 in thick newly built as the original outer walls are not sufficiently strong.

Fig. 218 shows a section of a cellar in which in addition to supplementary walls on the inside, the roof also

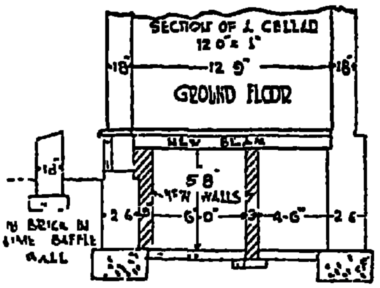


Fig 218

Section of a cellar. Outer weak wall is strengthened by a 9" brick in cement wall on the inside The roof is strengthened by supporting it by a new beam The span is also reduced by a new wall supporting the beam A baffle wall is built to protect the window from splinters & blast

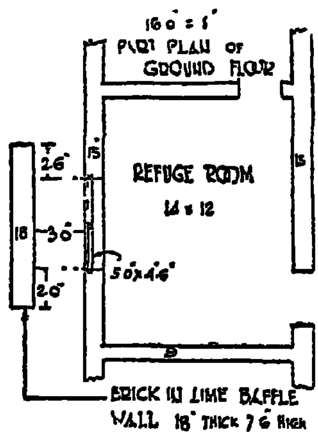


Fig 219

Part plan of ground-floor showing improvised refuge room The window is protected by the baffle wall on the left hand side, overlapping the window 2 ft on either side

is strengthened by supporting it by means of wooden joists laid on top of new walls. In a similar manner it is possible to strengthen the floor on the top of the improvised shelter either in a cellar or on ground-floor by giving supports in the form of new beams from below placed on top of wooden posts or walls newly erected.

For converting a room on the ground-floor into a refuge room. if the walls are strong enough, *i.e.*, at least 14" thick in lime mortar, to resist the action of splinters, the doors, if any. in the exposed wall and windows must be protected from blast This can be best done by erecting. in front of the openings at a distance of 3 ft, baffle walls of brick in lime mortar at least 14" thick. 7' high and of lengths equal to the widths of the openings plus 2 ft. overlap on either side as shown in fig. 219.

If there be an R.C.C. monolithic stair-case in the house the space below it, if suitably protected against blast by baffle walls, offers good protection.

Fig. 220 shows a suggestion for improvising a shelter just on the outside of the house, alongside an outer wall.

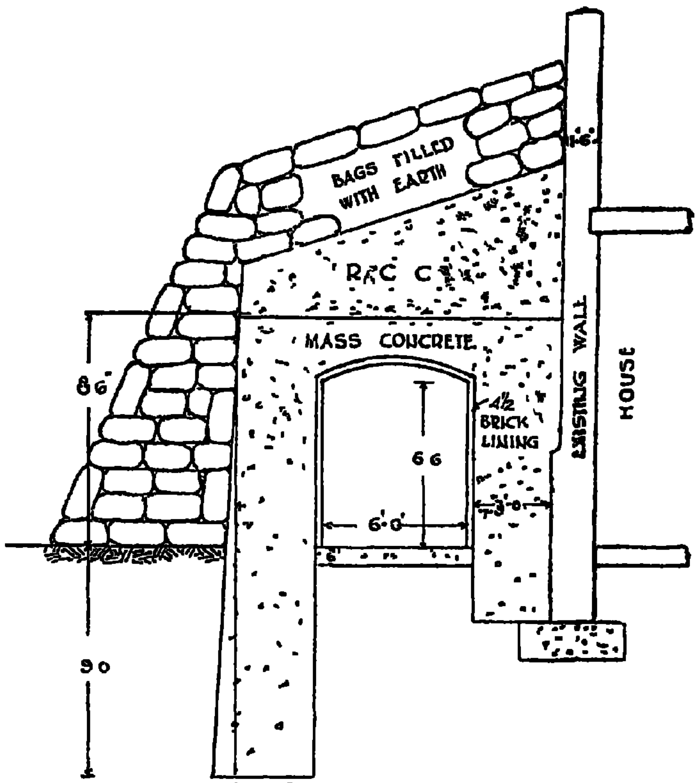
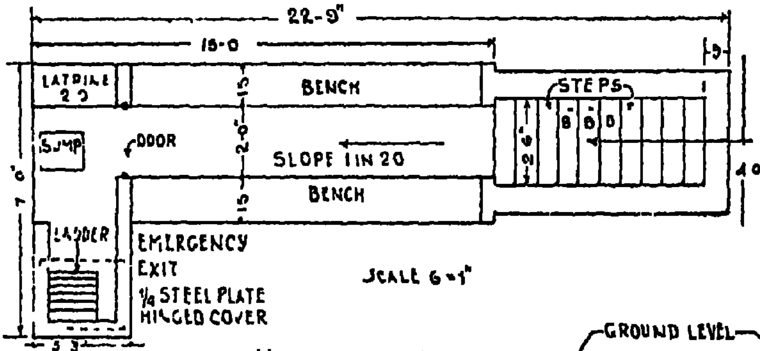


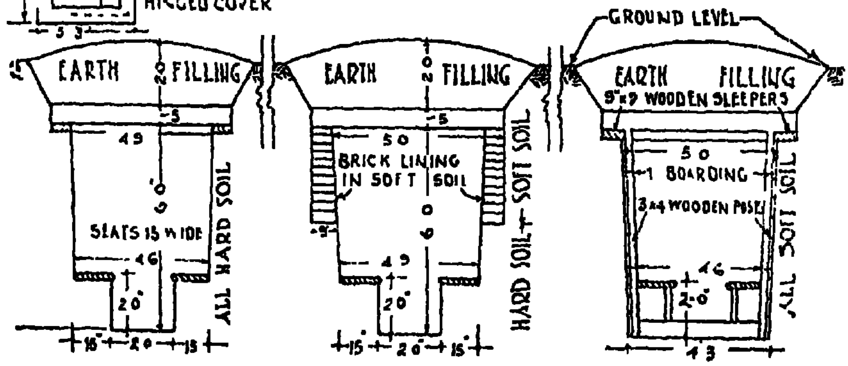
Fig 220
A shelter built on the outside of a house.

It is rather expensive but, it is designed to give protection not only from blast, splinters and collapse of the house, but also from direct hit of a high explosive bomb of medium weight The sketch which is a section of the shelter is self-explanatory. A narrow emergency exit is provided in the midst of the sand bags on the left-hand side, (not seen in the sketch).

Figs. 220 to 222 show covered trench shelters in the open space in garden. If any of the above shelters are not

Fig 221





Figs 222, 223 & 224

Top figure shows a plan of a covered shelter in compound with entrance steps, benches on both sides and an emergency exit ladder At top there is a 2 ft cover of earth on corrugated iron sheets supported by wooden joists. Fig 222 shows a section in hard soil, the sides of which can stand unsupported Fig 228 is a section in 2'-6" soft earth at top which is lined with 9" brick wall Fig 224 is a section in soft soil throughout The sides are supported by wooden boards

feasible. such trench shelters should be located at a distance from the house, equal to the height of the building so that in the event of the collapse of the latter, the shelter should remain unaffected. Fig 220 shows a shelter in murum or very soft rock. Fig. 221 shows it when murum is met with at half the depth and fig. 222 shows a shelter built wholly in soft soil. In the latter case wooden boarding which is not attacked by white ants is laid behind posts to support the sides of soft clay

The width of the trench at bottom is 4'-6", divided into two benches for sitting on both sides 1'-3" wide, and 2 ft of leg room between them. The height of the shelter is 6'. There are steps on one side for entrance and a ladder on the opposite side to provide an emergency exit. On the top of the opening for the ladder is placed an iron plate. either hinged to a frame so that it can be lifted up for exit or it may be mounted on rollers for being pushed aside

The roof on the trench is formed of wooden joists 4"×3" laid crosswise with their ends resting on timber wall plates. On top of the joists rest galvanised corrugated iron sheets and above these is a covering of earth about 2 ft. thick Grass or small plants may be grown on the latter for camouflaging.

APPENDIX I

BUILDING MATERIALS

Stone Stone may be either (1) of igneous origin such as granite, trap, basalt, etc or (2) of aqueous or sedimentary origin, being deposited under water, and hardened by pressure and cementing material, such as sand-stone, limestone etc, or (3) of rocks originally aqueous but subsequently undergoing changes due to heat and pressure under earth's surface These are called metamorphic rocks such as marble, slate, schists, etc

The requirements of a good building stone are that (1) it should be durable, *i.e*, should resist the action of atmospheric agencies, such as heat, cold, piercing rain, acids dissolved in rain water, etc These tend to either discolour or wear it out (2) it should possess ease of dressing For this purpose it must be close-grained, homogeneous and comparatively soft (3) it should have a good appearance The colour of the face should harmonise with the general architecture of the building and (4) it should not have flaws or cracks and it should give a clear ringing sound when struck with a hammer

There is quite a large range of excellent stones available in India suitable for every purpose. For example, *granite* in South India, Gujarat, Raichur and Kanara District of Bombay, granite takes an excellent polish and is a very hard, durable and heavy stone

Trap and Basalt of the Deccan and Central Provinces and Central India are a very hard igneous rocks, strong and durable but difficult of dressing

Sand-stone is obtained in various colours, grey, white, red purple, blue and yellow. Excellent sand-stone is obtainable in Gwalior, Agra, Patna, Gujarat, Belgaum Bikaner, South India, Kaimur rocks at Chunar, Damuda Valley, etc

Gneiss is similar to granite except that it shows stratification. Available in Bengal, Mysore and Madras

Slate is obtainable in Rajputana, Kangra Valley, Chamba and Rewari near Delhi

Limestones in various colours such as, white grey, black, red and yellow —at Porebunder Katni, Shahabad, Kadappa, Mirzapur, Jubbulpore and most other parts of India

Marble of India has been very famous Thus white marble of Makrana quarries in Jodhpur and Kharwa in Ajmer are well known Yellow marble of Jaisalmer known as 'Khattu' has been famous from ancient times Green mottled marble of Motipura in Baroda State, Serpentine marble of Kadappah and Karnul, Pink marble of Kishengarh and Black marble of Nimkhera in Central India and Chitor are well known

Laterite is a brick coloured soft stone It is soft when freshly quarried and becomes hard by exposure It is available in the South of Deccan, Orissa, Midnapur, South India, Malbar, etc.

All stones, and particularly those of stratified (aqueous) origin should be laid flat on their natural bed in structure

BRICKS

The standard size of bricks is $9'' \times 4\frac{1}{4}'' \times 2\frac{1}{2}''$ though the size varies according to local practice in India Thus besides the standard size, there are three more sizes current, *viz*, $5'' \times 3\frac{1}{2}'' \times 1\frac{1}{2}''$, $8'' \times 4'' \times 1\frac{1}{2}''$ and $10'' \times 5'' \times 3''$ The latter size is most common in United Provinces and Bihar

The characteristics of a good brick are that it should be so hard that it should not be possible to make a scratch on the surface with the finger nail, it should give a ringing sound when struck, it should be heavy, and if allowed to drop flat from a height of 3 ft. on a hard ground, should not break, it should not absorb more water than $\frac{1}{6}$ of its own weight, if kept immersed for two hours in water It should have all faces perfectly rectangular and all edges sharp It should be free from any lumps and the most important test is that, if 5 or 6 bricks selected at random be kept immersed in water over night, none of them should show a crack and a tendency to fall to pieces If this happens, the bricks contain particles of lime kunker in its clay, which have been converted into quick lime by burning These bricks are unsuitable for work

Colour of bricks is no test, because, it depends upon the nature and constituents of the clay and the fuel used for burning

Bricks are moulded in two ways one is called slop-moulding in which the mould is dipped into water every time, to prevent the 'green' brick from sticking to it. This causes surface cracks and the bricks do not keep their shape so well. In the other method called sand-moulding, the mould is sprinkled with or dipped into fine dry sand or ashes, before it is filled with clay. This results in producing bricks more shapely and with sharper edges.

Further, bricks are moulded either on ground or on a table In the former method the moulds used are made of wood and as the ground surface is not so smooth, the brick does not become smooth on that side—these are called "country bricks" In the other method the bricks are moulded in brass moulds on a table and each brick is moulded on a wooden or metal palet This results in giving them a more regular shape and smoother surface

Table-moulded bricks, which are usually sand-moulded, are much costlier than ground-moulded which may be even slop-moulded. However, if the surface of walls is to be plastered for appearance and keeping out rain, country bricks (ground-moulded), provided they are well burnt and satisfactory in other respects may be safely used from the point of view of economy.

Sand This should be coarse, clean, hard, strong, uncoated and free from clay, dust, mica and soft flaky particles such as of shell. Crushed stone is also used but it should be free from excessive proportion of very fine particles like dust Sand required for mortar for brick-work needs to be sieved through a $\frac{1}{8}$ in mesh sieve

Surkhi Where sand is not available or is very costly, surkhi is substituted in preparing lime mortar. It generally consists of crushed brick-bats, but when these are not available in large quantities, round balls of clay are made, burnt into kiln and crushed or ground to fine powder The best surkhi is made of clays containing 10 to 20% of lime kunker and this should be under-burnt Clay containing little or no lime must be thoroughly burnt to bring out the excellent quality of surkhi from it.

Surkhi should not be used in lime mortar for plaster, since it is likely to disintegrate after a time due to destructive agencies of atmosphere.

LIME

There are two varieties in lime (1) fat and (2) hydraulic Fat lime is obtained by burning pure chalk ($CaCO_3$), marble or sea-shells It is the lime eaten with beetle-leaves (*Pan*) When such pure lime-stone is burnt in kilns, it forms lumps which are called quick lime If water be added to quick lime it 'slakes', *i e*, absorbs water, swells to twice or more of its bulk, gives out considerable heat and makes hissing and cracking noise and falls to powder. This lime becomes moderately hard when it comes in contact with carbonic acid gas in the air. Moisture or water has no action on it. The mortar made of this lime, therefore, hardens near the surface and that

in the interior remains soft and has no cementing value. Another characteristic of fat lime is that when it dries it shrinks excessively which results in the formation of cracks This tendency can be considerably reduced by mixing sand with it Sand, further, makes the mortar porous and gives it a better chance of absorbing carbonic acid gas from the air and improves its setting power Usually, two to three times as much of sand as the quantity of fat lime is used for preparing mortar Even then the mortar is not very satisfactory in respect of strength for binding pieces of stones or bricks together in masonry

If the fat lime is mixed with surkhi in fine powder, the mortar produced will set or harden both under water and in the air and will give good results in respect of strength But if 20 to 30% of clay and a little proportion of magnesia and iron are found in the natural lime-stone and the latter is burnt, the lime produced will set more rapidly and acquire greater strength Such a lime is called hydraulic lime, from its quality of setting better under water than in the air

Lumps of hydraulic lime even fresh from a kiln take a long time to slake and develop very little heat There is very little or no cracking and no powder is produced If a lump of such hydraulic lime, either pure or mixed with sand, is kept immersed in water, it becomes firm in a day, hard in 3 or 4 days and very hard in a month and its strength goes on increasing even afterwards though at a very slow rate It is, therefore, necessary to test the hydraulicity of slaked lime before it is purchased for building work, and if only hydraulic lime is used, it is quite necessary *to keep the work moist at least for fifteen days*

Lime Mortar—Mortar of lime is prepared by grinding a mixture of lime and sand or surkhi If it is a fat lime, sand in the proportion of 2 to 3 times is quite necessary, firstly, to reduce its shrinking and cracking and secondly, to improve its setting power by absorption of carbonic acid gas. Hydraulic lime also has a tendency to shrink, though to a much less extent and so sand is added to cure it, for, sand also increases its bulk and reduces cost. Excess of sand, however, will weaken it $1\frac{1}{2}$ to $2\frac{1}{2}$ times is the proportion of sand usually adopted, in hydraulic lime

Fat or feebly hydraulic lime mixed with finely ground surkhi in the proportion of 1 to 2 or $2\frac{1}{2}$ produces a fair mortar with considerable strength and hydraulic properties. The mixing, however, must be very intimately made in a mortar mill Sometimes, both sand and surkhi are mixed in equal or varying proportions.

Preparation of mortar is a work which goes on for months together from the beginning to the end of the building work and as it thus becomes a routine it is likely to be neglected In these days cement which is always of uniform quality is fairly cheap and its mortar with sand or surkhi in the proportion of 1 10 or even 1 8 compares favourably as regards cost and strength as discussed in a previous chapter (vide pages 113 to 118). If however, on account of transport difficulties cement is costly, or good hydraulic lime be available at a very reasonable rate the following precautions may be taken while preparing lime mortar

(1) Only hydraulic lime should be used Before purchasing it a simple test may be made by preparing a few briquettes say, in the inner frame of a match-box with the bottom removed using a stiff mortar of one part of lime to two of sand They should be kept covered under a moist cloth for 48 hours If they have become firm by this time and cannot be easily crushed with fingers, it is a good sign These should then be kept immersed under water for a week If they be now hard with all the edges straight and fine it is undoubtedly a good hydraulic lime

(2) If the work is given by contract, the contractor or his men are apt to stint on the quantity of lime. If the proportion of lime to sand or surkhi is 1 . 2 as agreed upon he would use 1 4 or even more Hence, on a dry, flat, clean ground, free from dust, a flat layer of sand should be spread of a uniform thickness of 6 in by filling cub ft measures of sand flat upto top say 100 in number; on the top of this spread a uniform layer of 3″ of lime also by measurement (50 measures in this case) then again one 6 in layer or 100 measures of sand and 3 in layer or 50 measures of lime on top of these Mix this thoroughly in a dry state by turning over the heap twice The quantity needed for a week s requirement should thus be once measured and then the number of baskets from this heap should be put into the mortar mill

(3) Even if the work be done by departmental agency this should be insisted upon. Because otherwise, the tendency on the part of coolies employed on filling the *ghani* is to fill baskets of sand only half full to save them the physical effort as sand is heavy and fill those of lime which is light, full The result is that the mortar is unnecessarily rich and costly.

(4) The object of grinding mortar is two-fold (*a*) to break and crush the particles of unslaked lime and (*b*) to thoroughly mix the sand and lime so that every individual particle of sand is surrounded by a film of lime.

Hence, mere grinding by the wheel (if bullock driven mortar mill is employed) is of no use The mortar must be turned over continually by the 'spoon' which a boy is employed to hold behind the millstone. Again, the tendency of the driver who generally owns the bullocks is to make the mortar too wet to lighten the work of the bullocks This causes the particles of sand and unslaked lime to slip away from the stone wheel

(5) There should be some infallible fool-proof arrangement attached to the mill axle, like a telltale of screw threads and a nut on the central pivot so that the mill-man must make the fixed number of rounds without being constantly watched

(6) If mortar once ground remains unused for a few days, it should be broken on every 3rd day, water sprinkled on it and remixed and kept in a heap If it remains unused for more than 7 to 10 days it should be finally put into the mill, a few baskets of fresh slaked lime added to it, watered and a few more rounds of the millstone made before the mortar is used

(7) Both the mortar which is ground and the slaked lime or the dry mixture of slaked lime and sand, referred to in (2) above, particularly the latter, should be well protected from rain Slaked lime soaked with rain-water, if not used within three days, should be rejected.

(8) Mortar should be used as stiff as possible in masonry work

(9) Slaked lime sold by petty dealers is likely to be adulterated with white clay When this lime is ground in a mill the mortar becomes sticky and cannot be distinguished from good mortar It is, therefore, advisable to get quick lime on the site of building, and get it slaked there before buying it

TIMBER

The characteristics of good timber are given below:—

(*a*) The rings in a transverse section should be narrow indicating strength on account of slow growth of the tree

(*b*) The colour should be dark.

(*c*) A freshly cut surface should smell sweet, be firm and shining A dull, chalky or wooly appearance is a sign of bad timber

(*d*) It should be sonorous when struck; a dull, heavy or hollow sound indicates decay inside

(e) Among the same species the heavier specimen is better

(f) Only seasoned wood should be used in buildings, otherwise it is likely to shrink, split, warp or crack A freshly sawn surface of unseasoned wood gives a characteristic smell of wetness and also is moist to the touch

(g) Sound timber should be free from decay at the heart large knots and cracks

(h) Planks and scantlings should be free from sapwood (wood of lighter colour near the bark), of proper and even thickness and section with all the edges unbroken

A Practical hint Cutting and sawing timber from logs or balks should not be tried by laymen, since, it is a risky business The purchase of logs requires experience Then, sawing also requires experience care and constant supervision The waste timber obtained cannot be economically utilised on the building work and thus forms a cumbersome heap worth not more than its fuel value Besides, for want of getting scantlings of the required size in time the progress of the work is hindered

The surface of timber in contact with masonry should be coated with hot coal-tar before it is laid in position

The greatest enemy of timber is *dry rot* It is a kind of fungus which eats into the entire piece of timber though apparently it looks sound. It is detected by the hollow sound which it gives when tapped on the surface If the surface is cut or bored by an auger the fibres will be seen to have been reduced to powder by the dust coming out The cause is damp either inherent in the unseasoned wood or outside, and want of ventilation. If the timber is previously well seasoned and thoroughly dry one or two coats of timber-preservatives, or oil paint will serve as a preventive remedy. Oiling (vide page 251) and varnishing is also a good remedy

Measurement of timber Timber is measured by cub. ft Usually 50 cft is taken to be one ton The usual method of measuring round or roughly squared log or balk of timber is to measure the girths at both the ends and in the middle Thus if G1 G2 and G3 are the girths at one end centre and the other end then the cubic contents$=\frac{(G_1+G_2+G_3)^2}{9}\times$ length. If the log is of almost uniform diameter its cubic contents can be roughly found out by measuring the girth G2 at the mid-length only and calculating $\frac{(G_2)^2}{4}\times$ length.

A few important Indian timbers in common use for house purpose are described in the following table with their names in regional languages as far as available

Besides the Indian timbers given in the table, Australian Mahogani, called *Jarrah* has been in very common use in India, its colour is warm-brownish red, grain rather coarse and porous It is very heavy and durable under water It is used for all house work, but is not suitable for furniture

Planks of pine wood 8 to 18 in wide, one inch and above in thickness and of any length upto 24', are commonly used for scaffolding work. They are imported from Singapore, Australia, New Zealand, etc. The wood is soft, tough, elastic, reddish brown or whitish or grey in colour The fibres are straight, the lateral adhesion of fibres being week it easily splits It is very good for resisting pull or tension It is, however, liable to warp and crack at ends

A FEW IMPORTANT INDIAN TIMBERS SUITABLE FOR HOUSE BUILDING.

No	Popular Name	Botanical Name	Hindi	Bengali	Marathi	Gujarati	Tamil	Telugu	Malayalam	Kannad	Description and uses
1	Anjan	Hardwickia binata	Anjan		Anjan	Anjan	Alti	Yepi	Uram	Kamra	Sapwood white, heart wood dark red, streaked with black extremely hard and heavy, sinks in water, very close grained, hard to work, does not warp, but liable to split, used for posts, beams, bridges, Rly sleepers, cart wheels, ploughs, etc
2	Ain	Terminalia-tomentosa	Sain	Usan	Ain	Sadri	Anemui	Maddi	Them-banu	Matti	Sapwood reddish white, heart wood dark brown, white darker streaks, undulating, fibrous, heavy, durable under water, not affected by white ants but cracks badly by exposure Used for all house work, excellent for fuel and charcoal
3	Arjun	Terminalia Arjuna	Arjun	Arjun	Arjun	Arjun Sadra	Vella-matti	Tela-madu	Vela-maruthu	Hole-matti	A large tree, wood brown with darker streaks, very hard and durable, difficult to work, apt to split, used for all house purposes, cart wheels, ploughs and other implements, boats, etc, fine for avenues
4	Babul	Acacia Arabica	Kikar, Babur	Babla	Babul	Baval	Karu-velam	Tuma	Karu-velam	Jali	Moderate size, wood redish brown, used for cart wheels, agricultural implements, tool-handles, well curbs, etc, large scantlings scarcely available, excellent for fuel and charcoal

No	Popular Name	Botanical Name	Hindi	Bengali	Marathi	Gujarati	Tamil	Telugu	Malaya-lam	Kannad	Description and uses
5	Chir (Blue pine)	Pinus excelsa	Kail, chir								Large evergreen tree, wood light red, moderately hard, Popular next to Deodar in Kashmir and the Punjab, planks superior to Deodar, used for all house work, not eaten by white ants
6	Deodar Hima-layan Cedar	Cedrus libani									A very large and tall tree, wood, light yellowish brown, strongly scented, oily, the chief timber of N. India, used for all house purposes, Rly sleepers, not eaten by white ants
7	Jambu (Iron wood)	Xylia dolebri-formis	Jambu		Jamba	Jamba	Irul	Tangedu	Kada	Jamba	Large tree, wood dark red, extremely hard The most important timber after teak of Burma and S India, very durable, not attacked by white ants, useful for every purpose, Railway sleepers, bridges, boats, carts, piles, etc
8	Jambul	Eugenia-Jambo-lina	Jaman	Jam	Jambul	Jam-budo	Nawal	Neredu		Nerlu	A large tree, wood reddish grey, durable specially under water, useful for well curbs, house building, agricultural implements, liable to be attacked by insects
9	Mango	Mangifera indica	Am	Amra	Amba	Ambo	Mangas	Mamdi	Mavu	Maven	A large evergreen tree, grown all over India, grey or dark-brown wood, used for planks, doors and window-frames, packing cases Eaten by insects

No	Popular Name	Botanical Name	Hindi	Bengali	Marathi	Gujarati	Tamil	Telugu	Malayalam	Kannad	Description and uses
10	Nim	Margosa-indica	Said		Limb	Limdo, Kohumba	Vepa	Yepa		Bevu	A large evergreen tree, wood reddish grey, durable, used for doors and window-frames, carts, ship-building
11	Sal	Shorea-robusta	Sal	Shal				Gugal			A large evergreen tree, wood dark brown, coarse-grained, fibre hard, cross-grained, most extensively used in N India for piles, all house work, bridges, gun carriages, etc
12	Sida	Lagerstromia parviflora	Sida	Sida	Nana	Kakria	Venteak	Ventaku	Sanjal	Ventaku	A large tree, wood reddish brown, very useful for building purposes, ships, furnitures
13	Sissu	Dalbergia Sissoo	Sisham, Sissu	Shishu	Sisva	Sisam	Yette	Sissu		Biridi	The rose wood of India wood dark purple, extremely hard, close-grained, very durable, does not warp nor split Very useful for every purpose But, since it is very valuable for ornamental work, it is not available for building work
14	Teak	Tectona-grandis	Sagun	Shegun	Sag	Sag	Tak	Taku	Tekku	Tega	A large tree, wood dark golden yellow, moderately hard, strong and durable The chief export timber of India and Burma Useful for all building work, furniture, ship building, Rly sleepers, not eaten by white ants
15	Tun	Cedrela-toona	Tun	Tuni, Lud	Kuruk	Thevatheram	Santhana Vembu		Mathagiri Vembu	Tundu	A large tree, wood brick red, soft, shining, fragrant, even-grained, neither splits nor warps, durable, not eaten by white ants, highly valued for furniture, also all building work, carving, etc

IRON

Iron is the most commonly used metal in building work in either of the three forms Cast iron, Wrought iron or Steel

(*a*) Cast iron is obtained by melting iron-ore and broken lime stone in a blast furnace and running it into moulds of the required shape. Cast iron contains 2 to 6% of carbon It is, therefore, brittle and cannot stand shocks It is used for bases of columns, ornamental railing, lamp-posts, water pipes, hollow columns, etc A good casting of cast iron should be smooth and clear with sharp edges Uneven or wavy surface indicates unequal shrinkage The surface of a fresh fracture of the casting should show a fine grained texture of bluish grey colour and high metallic lustre Air bubbles inside a cast iron casting are dangerous It should, therefore be tapped all over the surface with a hammer, if it sounds hollow anywhere it is a sure sign of air bubble and if it sounds dull, there is a crack or a fracture somewhere

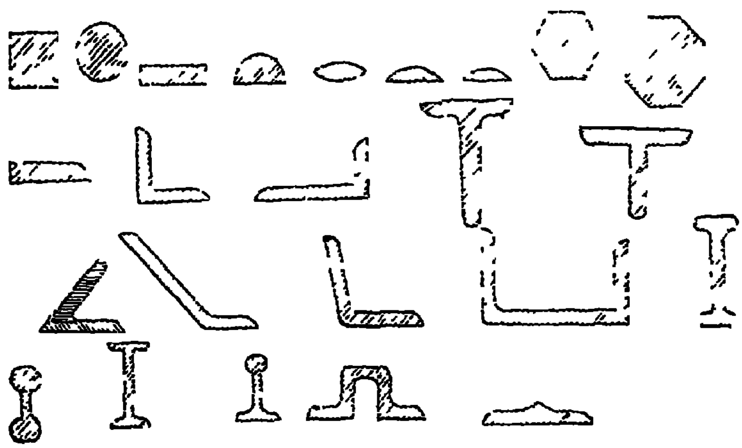
(*b*) Wrought iron is very nearly pure iron with carbon contents scarcely exceeding 25% The qualities of good wrought iron are A fresh fracture should show blush grey, silky, fibrous appearance At white heat it should become soft enough to take any shape under the hammer and admit of easy welding with another piece equally heated

Wrought iron is now rarely used for structural work, its place having been taken by mild steel Screws, nails, small diameter pipes and water fittings, etc, are still made of wrought iron Similarly, plate, sheet and hoop (flat strip) iron and the flexible wire, such as is used for R C C work rivets, bolts, bars under 2 inches diameter, galvanised corrugated sheets are all made of wrought iron The latter are coated with zinc

Steel Steel is manufactured by first removing all the carbon from it and then introducing in it a measured fixed proportion of carbon again according to the quality required for different purposes The proportion of carbon varies from 1% in extra soft steel to 1 5% in tool steel The steel for machine-tools, files, chisels, dies, etc, contains a high percentage of carbon which makes it brittle, but very hard Sometimes, the surface of steel which is subjected to considerable wear such as in toothed-wheels of a lathe, cycle bearings, etc, the article is "case-hardened" by packing it in animal matter such as bones, hide, hoops, horns, etc., and then heating gradually at a high temperature and cooling it in water Steel takes a 'temper,' *i e*, when heated to a dull red heat and then suddenly cooled in water, it becomes hard

and brittle Axes scycles knives razors and other tools are tempered like this and then sharpened by grinding

The steel used for structural parts such as Tees angles girders, etc, for buildings bridges and other structures is called mild steel Transverse



Figs 225 to 248 showing sections of different forms of mild steel manufactured in standard sizes

sections of the different forms of mild steel such as flats squares and round bars Tees angles girders, etc, are shown in figs 225 to 248 These are all standardised in size and weight

The following tables give the sizes and weights of some of the important forms in common use

Steel sheets These are either uncoated or galvanised *i e* chemically coated with zinc

Plane steel sheets are available in 6 to 12 ft lengths and 3 or 4 ft widths and of thickness from 1/16 inch to one inch, varying by 1/16 inch The weight of 1 16 inch plane sheet is 2 55 lbs per sq ft. From this the weight of steel of any thickness can be worked out *e g*, the weight of 1/8" sheet is $2.55 \times 2 = 5\ 10$ lbs that of 1/4" sheet is $2\ 55 \times 4 = 10\ 20$ lbs per sq. ft and so on

Galvanised sheets are of two kinds · either plane or corrugated Their thickness is measured not in inches but in Burmingham wire gauge (B W G) They are available of thicknesses varying from 18 to 26 B. W. G and in two widths *viz*. 26 in and 32 in C I Sheets used for roofing

are usually of 22 gauge. The following table gives details about them :—

Length in ft.	26" width with 8 corrugations, weight in lbs				32" width with 10 corrugations, weight in lbs			
	18 B.W.G.	20	22	24	18 B.W.G	20	22	24
6	31	24	19.5	16	36	28.5	23	19
7	36.5	28	23	19	42.5	33	27	22.5
8	41.5	32	26	22½	49	38	31	25.5
9	46.5	36	29.5	24	55	42.5	34.5	29
10	52 5	39	32	27	61	48	39	32

The shorter lengths of C.I. Sheets cost slightly more. The C.I sheets are packed in bundles of 2 Cwts. each

For fixing C.I. Sheets on roof 2¼ to 2½ inch. galvanised screws are used. These are sold by weight. One Cwt. contains 24 gross (one gross= 12 doz.) of the former and 20 gross of the latter For joining two sheets together galvanised bolts are used which also are sold by weight

One Cwt contains 32 gross of bolts 1/2" × 1/4"
" " 31 " " " 3/4" × 1/4"
" " 24 " " " 1¼" × 1/4"
" " 22 " " " 1½" × 1/4"

Weights and Areas of squares and Rounds
Weight per cubic Foot of Steel=489.6 Lbs.

Thickness or Diameter	Weight of ○ Bar One ft. lg	Weight of □ Bar One ft lg.	Area of ○ Bar in sq. inches	Area of □ Bar in sq. inches
¼	167	212	0491	0625
5/16	261	332	0767	.0977
3/8	376	478	1104	1406
7/16	511	.651	1503	1914
½	668	850	1963	2500
5/8	1 043	1 328	3068	3906
¾	1 502	1 913	4418	5625
7/8	2 044	2 603	6013	7656
1	2 670	3.400	7854	1 0000
1¼	4 172	5.313	1.2272	1 5625
1½	6 008	7.656	1.7671	2.2500
1¾	3 178	10 41	2 4503	3 0625
2	10.68	13.60	3 1416	4 0000

HOOPS OR FLAT BARS

Thickness in inches	½"	5/8"	¾"	7/8"	1"	1¼"	1½"	2"	2½"
¼	.425	.535	.638	.742	.850	1.06	1.28	1.70	2.13
5/16	.531	.664	.797	.924	1.06	1.33	1.59	2.13	2.66
3/8	.638	.797	.956	1.12	1.28	1.59	1.91	2.55	3.19
7/16	.760	.940	1.12	1.30	1.49	1.86	2.23	2.98	3.72
½	.861	1.07	1.28	1.49	1.70	2.13	2.55	3.40	4.25
9/16	.960	1.20	1.43	1.67	1.91	2.39	2.87	3.83	4.78
5/8	1.07	1.34	1.60	1.87	2.13	2.66	3.19	4.25	5.31
11/16	1.15	1.44	1.74	2.03	2.33	2.92	3.51	4.68	5.84
¾	1.28	1.60	1.91	2.23	2.55	3.19	3.83	5.10	6.38
13/16	1.38	1.72	2.07	2.41	2.76	3.45	4.14	5.53	6.91
7/8	1.46	1.84	2.21	2.59	2.96	3.71	4.46	5.95	7.44
15/16	1.58	1.98	2.38	2.78	3.18	3.98	4.78	6.38	7.97
1	1.70	2.13	2.55	2.98	3.40	4.25	5.10	6.80	8.50

TABLE OF ANGLE (L) IRON

Size in inches	Weight per ft. length	Size in inches	Weight per ft. length
1 ×1 ×1/8	.80	3 ×3 ×1/8	4.90
” ” ×3/16	1.15	” ” ×3/16	6.05
” ” ×¼	1.49	” ” ×¼	6.18
1¼×1¼×3/16	1.47	” ” ×½	9.36
” ” ×¼	1.91	3½×3½×3/8	8.45
1½×1½×3/16	1.79	” ” ×½	11.05
” ” ×¼	2.33	4 ×4 ×3/8	9.72
1¾×1¾×3/16	2.11	” ” ×½	12.75
” ” ×¼	2.77	” ” ×5/8	15.67
2 ×2 ×3/16	2.43	5 ×5 ×½	16.15
” ” ×¼	3.19	” ” ×¾	23.59
2½×2½×¼	4.04	6 ×6 ×½	19.56
” ” ×5/16	4.98	” ” ×5/8	24.18
” ” ×3/8	5.89	” ” ×¾	28.70

TABLE OF TEE (T) IRON

Size in inches	weight per ft. length.	Size in inches	Weight per ft. length.
1½×1½×¼	2.35	3 ×3 ×½	9.38
1¾×1¾×3/16	3.40	3¼×3¼×3/8	8.49
" " ×¼	2.79	" " ×½	11.08
1½×2 ×5/16	3.41	4 ×4 ×3/8	9.77
" " ×¼	2.79	" " ×½	12.78
1½×2 ×3/8	4.01	5 ×3 ×3/8	9.78
2 ×2 ×3/8	4.64	" " ×½	12.79
" " ×¼	3.22	5 ×4 ×½	14.51
2¼×2¼×3/8	5 28	" " ×5/8	11.07
" " ×¼	3.64	6 ×3 ×½	14.53
2½×2½×3/8	5.92	" " ×5/8	17.87
" " ×5/16	5.71	6 ×4 ×3/8	12.36
" " ×¼	4 07	" " ×½	16.28
3 ×3 ×3/8	7.21	" " ×5/8	19.99

BRITISH STANDARD SECTIONS OF ROLLED STEEL GIRDERS OR I-BEAMS

B.S.B. No.	Size in inches	Weight per foot lbs.	Area of section sq inches	B S B. No	Size in inches.	Weight per foot lbs	Area of section sq inches
1	3 ×1½	4	1.176	16	9×7	58	17.06
2	3 ×3	8.5	2.5	17	10×5	30	8.82
3	4 ×1¾	5.0	1.47	18	10×6	42	12.35
4	4 ×3	9.5	2.794	19	10×8	70	20.60
5	4¾×1¾	6.5	1.912	20	12×5	32	9.41
6	5 ×3	11	3 235	21	12×6	44	12.94
7	5 ×4½	18	5.29	22	12×6	54	15.88
8	6 ×3	12	3.53	23	14×6	48	13.53
9	6 ×4½	20	5.88	24	14×6	57	16.76
10	6 ×5	25	7.35	25	15×5	42	12.35
11	7 ×4	16	4.706	26	15×6	59	17.35
12	8 ×4	18	5.294	27	16×6	62	18.23
13	8 ×5	28	8.24	28	18×7	75	22.06
14	8 ×6	35	10.29	29	20×7½	89	26.17
15	9 ×4	21	6.176	30	24×7½	100	29.4

There are two varieties in girders (1) British standard sections as above and (2) *continental manufacture.* The former are more reliable. The continental sections weigh slightly more Tata Iron and Steel Co. also manu-

facture most of the above sections in India Girders are available in lengths up to 40 ft It is possible to obtain girders in pieces of the required lengths If one or more pieces are bent they should be straightened by hammering in a cold state Any little rust should be soaked with kerosine oil and then scrubbed with a stiff wire brush

GLASS

Glass used in building is of various sorts For window-panes either *window glass*, which is $\frac{1}{12}$ in thick and weighs 16 08 oz. per sq. ft or *sheet glass* $\frac{1}{10}$ to $\frac{1}{8}$ in thick weighing 21 to 24 oz per sq ft is used

For window-panes "fluted" glass is often used The fluting on one side strengthens the glass gives diffraction of the light rays with apparent increase of light and eliminates complete transperency

Rolled glass from thickness of $\frac{1}{8}$ to $\frac{3}{8}$ in is used for sky lights *Figured glass* is a variety of rolled glass This is obtainable in a variety of style from a simple hammered surface to elaborate floral designs This sort of glass is used for screens, for giving effective light and at the same time affording privacy This is obtainable in a variety of pleasing colours

Plate glass is obtainable of thickness of $\frac{1}{4}$" and above upto $1\frac{1}{2}$" This is more durable and very transperent, and is used for show-windows

Ordinary glass is made *opaque* either mechanically by sand-blasting or grinding with emery or chemically by an acid The former process imparts a rough surface to the glass while the latter gives it a smooth finish

Wired glass, both rough and polished, with either hexagonal or square mesh, is extremely useful for sky-lights roofs and A.R.P. The wire is embedded in the glass while rolling with the result that the pieces if broken are held in position

Safety glass, either two-ply or three-ply, consisting of two pieces of glass, between which is introduced a sheet of transparent celluloid or other suitable material, is largely used It is rather expensive It is almost a standard fitment for windows of automobiles This sort of glass absorbs moderate shocks and does not fly into splinters

Heat-excluding or anti-actinic glass is of special manufacture, which admits about 65% of sun s light and excludes well over 80% of its heat "Colorex" glass is one of them Sometimes, these are smoke-coloured

to present a further cooling effect by reducing glare. Such a glass is often used in the windows of I class Railway coaches

Ultra-violet Ray Glass This glass effectively transmits "health rays" present in the sun's light, which are mostly absorbed by ordinary window glass panes. "Vita" glass is a notable instance of such glass These glasses need not be exposed to direct sunlight The windows may be in any direction. Even the light diffused by blue sky and white clouds is very rich in ultra-violet rays.

Putty for wood-glazing is made by mixing powdered whiting (chalk) with raw linseed oil and kneading it well If a little white lead, red lead or litharge is added, its quality is at once improved. Stale and hard putty should be warmed and kneaded, to make it soft and workable.

Ply-wood. This is quite a modern building material. It is made of thin layers, plies or veneers of wood glued together with the grain of adjacent layers at right angles, pressed together in machines and dried The resulting material is a marvellous article combining beauty with great strength, lightness of weight, pliability, and of size impossible to obtain in solid wood.

At present there are five types of ply-wood obtainable.

1. *Three-ply* Panels made from three veneers with adjacent veneers at right angles, made in thicknesses from $\frac{1}{4}''$ to $1''$ and over

2. *Multi-ply* Made in any number of veneers and in thicknesses from $\frac{1}{4}''$ to $1''$ and over

3. *Laminboard*· Panels with a core of multi-ply veneers, each not exceeding $\frac{1}{4}''$ made into a solid block and re-cut edge-ways, glued, and laid between outside plies of thick veneers and pressed into sheets of thickness from $\frac{3}{8}''$ to $2''$ and over

4. *Battenboard* Panels similar to laminboard in construction, but with the core made from sawn thin wood $\frac{3}{4}''$ to $1''$ Thickness as that of laminboard

5. *Veneered Ply-wood*: Panels of the first four types with a ply of decorative wood of some kind glued either on one or both sides and pressed together

There are four main qualities "AA"or "A1", "A", "B" and "C" according to the absence of knots. The qualities "AA" and "A" have their surface smoothed ready for polishing

The word "Ply" does not convey any idea as to thickness. It simply means veneers glued together. Thus a panel $\frac{1}{4}''$ thick might be compiled with 3 plies, 4 plies or even 7 plies.

Plywood panels faced one side only with a decorative wood such as Oak, Mahogany, Walnut, etc., are cheaper than those faced both sides. Panels listed as, say, $60'' \times 48''$ have the grain running in the direction of the first dimension, *viz.*, $60''$ in this case.

Although of great strength, Plywood should not be used for purposes where it will receive direct knocks or heavy chafing.

APPENDIX II

SCHEDULE OF RATES OF LABOUR

A layman is very often confronted with a great difficulty when he has some work in connection with his home to be got done, particularly when it is a small job. As it is a petty work, people who are doing regular contracting business are not attracted to it. Were he to employ workers on daily wages, in the absence of efficient technical supervision, which the employer cannot afford for such a small work, not only does it become unduly costly, but it is not done also satisfactorily. If it were to be given to a petty piece-worker on a lump sum basis, the latter, who knows very well what it would cost him to do, demands at once four or five times as much, say, Rs. 100/-. The employer who has no idea that it would cost only twenty or twenty-five rupees, feels restrained while offering even fifty. the bargain is struck somewhere near sixty. But when the petty piece-worker after finishing it in 2/3 days at a cost not exceeding Rs. 15/- demands the amount agreed upon, the employer's eyes are opened, but as a gentleman he cannot go back upon his word

To meet such difficulties a schedule of detailed rates of labour of each trade in building construction is given here and it is hoped that it will prove of great practical utility. It must, however, be remembered that rates are bound to vary according to economic conditions of locality, nature and quality of material and casual fluctuations due to peculiar circumstances such as of war at present. Still, the variation will not be much—certainly it will be far too little as compared with the amount which the total ignorance on the part of the employer would cost him. The rates are of course of normal peace time.

Item No	Description	Unit	Rate Rs	a	p.	Remarks
	EXCAVATION					
1	Excavation in ordinary soil, sand, dry or moist clay including a lift of 5 ft and carrying materials to within 50 ft and stacking there	% cft	0	8	0	
2	" , stiff wet soil or clay	"	0	12	0	
3	, ,, Soft murum	"	0	14	0	
4	, Hard ,,	"	2	8	0	
5	" " " and boulders	"	3	0	0	
6	" " soft rock	"	5	0	0	
7	, hard rock by blasting	"	6	0	0	
8	" " " " by chisel	"	14	0	0	
9	Extra carriage of materials to 25 ft and more	"	0	2	0	by head load
10	" , 50 to 100 ft	"	0	3	0	
11	100 to 250 ,,	"	0	4	0	
12	250 to 660 ,,	,	0	8	0	
13	660 ft to 3 furlongs	"	1	0	0	by donkeys
14	, 3 furlongs to 1 mile	"	1	0	0	by bullock carts or motor lorries.
15	, ,, every extra mile	"	0	8	0	
16	Extra lift per foot	"	0	2	0	
17	Dismantling masonry and carrying the stuff to within 50 ft and stacking neatly	"	2	0	0	
18	Driving teak or sal piles 7" to 8" diameter for foundations with hand pile driver	rft	0	2	0	
19	Shoring trenches with close wooden boards and strutting	rft	0	1	0	
	CONCRETE					
20	1½" stone metal and lime concrete including mixing laying and ramming	% cft	3	8	0	
21	" " brick ballast 1½" and lime concrete	,	2	8	0	
22	1½" stone metal, sand and cement (6 3 :1) concrete in foundation	,	5	0	0	
23	" " 4 2 1 for R. C. C work	"	5	8	0	
24	Breaking brick ballast (Khoe) 1½" size	"	2	8	0	
25	Breaking stone metal 1½"	"	4	8	0	
26	Screening sand and gravel	"	1	0	0	
27	" stone metal	"	1	8	0	
28	slaked lime	"	0	14	0	
	DRESSING STONE					
29	Dressing stone ashlar fine	% rft	35	0	0	
30	, rough tooled with one inch chisel draft	"	15	0	0	
31	Quarry faced with one inch chisel draft	"	12	8	0	
32	6" Khandkis	% cft	2	0	0	
33	8" ,	"	2	12	0	
34	, 6"×9"×6' corners	100No	5	0	0	
35	, stone corners 8"×12"×9"	"	6	4	0	
36	, , 12"×12"×18"	"	20	0	0	
37	,, headers one-faced	"	4	0	0	
38	, " " two-faced	"	5	0	0	
39	Flagstones straight and square	% cft	1	8	0	
40	Rounding edges of 1½" flagstones	rft	0	1	0	
41	" and polishing of polished flagstone	"	0	4	0	

Item No	Description	Unit	Rate Rs. a. p.	Remarks
	SETTING MASONRY			
42	Uncoursed rubble masonry in foundation 2' 6" to 3' 0" thick	% cft	3 0 0	
43	Plinth masonry of Khandki facing and rubble backing 21" to 30" thick without pointing	,,	7 0 0	
44	Both faces rubble		5 0 0	
45	Superstructure of uncoursed rubble masonry class I with rubble backing 18" thick	,,	3 8 0	One Rupee should be added to these rates for every upper floor
46	,, ,, Khandki facing and rubble backing 18" thick	,,	3 8 0	
47	,, ,, both sides of rubble 18"	,,	7 0 0	
48	,, ,, Khandki facing and rubble backing 15" thick	,,	8 0 0	
49	Khandki facing rubble backing 15"	,,	9 0 0	
50	,, ,, 18" is mud	,,	6 8 0	
51	Both sides in rubble 18" in mud	,,	5 8 0	
52	Brick in lime 14" thick masonry 1st class	,,	7 0 0	
53	,, ,, 2nd class	,,	6 0 0	
54	,, ,, 9" to 10" thick	% sft	5 8 0	
55	,, ,, $4\frac{1}{2}$" to 5" ,,	,,	4 0 0	
56	,, ,, $2\frac{1}{2}$" to 3" ,,	,,	3 8 0	
57	Burnt brick in mud 14" ,,	% cft	5 0 0	
58	,, ,, ,, 9" ,,	% sft	4 0 0	
59	Pointing uncoursed rubble masonry (flat)	,,	1 4 0	
60	,, ,, Khandki face	,,	1 4 0	
61	,, ,, Brick masonry	,,	1 8 0	
62	Lime plaster to stone walls in three coats	,,	3 0 0	Annas eight should be added to these rates for every upper floor
63	,, ,, Brick masonry	,,	2 8 0	
64	Cement plaster sand grained on the exterior	,,	4 0 0	
65	Cement plaster on inner walls with a coat of neeru	,,	3 12 0	
66	Rough cast in cement on the exterior face	,,	2 8 0	
67	Pebble dash ,, ,, (superior)	,,	3 8 0	
68	Colorcrete or snowcrete in two coats	,,	6 0 0	
69	Brick in lime arch on top of door or window opening 2 to 4 ft span	each	1 0 0	
70	,, ,, 4' to 8' span	rft	0 8 0	
71	Flat brick arch 2' to 4' span	,,	0 8 0	
72	Filling R. C. C. lintel	,,	0 1 6	
73	Placing concrete in R C. C slabs including ramming	% sft	2 8 0	
74	,, ,, in R. C C beams	cft	0 1 6	
75	Constructing jack arches of brick in lime between joists without centering	% sft	9 0 0	
76	Cutting bricks, laying in mortar and finishing with plaster for cornice or string courses complete	rft.	0 3 0	
77	Erecting door and window frames in position in plumb	each	0 4 0	
78	Erecting door frame without sill including fixing pieces of iron bars at bottom and embedding in concrete	,,	0 6 0	
	PAVING			
79	Mud or murum flooring complete with ramming and finishing	% sft.	2 0 0	

Item No	Description	Unit	Rate Rs.	a	p	Remarks
80	One inch concrete floor (Indian Patent stone) on concrete already laid including surfacing	% sft	6	0	0	
81	,, ,, in colour patterns	,,	7	8	0	
82	1½″ flagstone paving with square joints including cement pointing and dressing flagstones	,,	3	8	0	
83	,, ,, diamond pattern	,,	5	0	0	
84	One inch polished flagstone paving with square joints	,,	6	0	0	
85	,, ,, diamond pattern	,,	7	0	0	
86	China glazed paving or lining to walls-plain	,,	8	0	0	
87	China glazed lining to walls including angle and coving pieces	,,	10	0	0	
88	China mosaic floor with coloured border and designs including breaking tiles	,,	15	0	0	
89	Brick on edge flooring over one brick soling in lime morter	,,	6	0	0	
90	,, ,, on two brick soling	,,	6	8	0	
91	Terrace flooring of 4″ beaten concrete and patent stone	,,	7	8	0	
92	One inch thick cement tile floor in coloured pattern without polishing	,,	8	0	0	
93	Hand polishing for above	,,	12	0	0	
94	Machine ,, ,, ,,	,,	8	0	0	
95	Marble flooring in patterns including polishing	,,	18	12	0	
96	,, ,, Plain (one colour)	,,	14	0	0	
97	Polishing (with hand) polished flagstone paving or Indian patent stone already laid	,,	2	0	0	
98	Pottery tile flooring square or hexagonal	,,	6	4	0	
	WOOD WORK					
99	Door frames of teak or sal 2 to 4 ft. wide 6 to 6½ ft length	each	1	4	0	
100	,, ,, with ventilator	,,	1	8	0	
101	Window frame single without ventilator	,,	1	4	0	
102	,, ,, with ventilator	,,	1	8	0	
103	,, ,, double (two bays) with ventilator	,,	2	0	0	
104	,, ,, treble (three bays) ,,	,,	2	12	0	
105	Planing, jointing and erecting frame work of wooden posts, post plates, beams, etc	rft.	0	2	0	
106	Wooden flooring on top of walls including beams, joists, boarding, etc., complete	% sft.	12	0	0	
107	Fixing iron bars in window frames	sft.	0	0	9	
108	Shutters of teak or sal plane planked (superior)	,,	0	8	0	
109	,, ,, 2nd class	,,	0	2	6	
110	,, ,, framed and braced	,,	0	3	0	
111	,, ,, panelled or glazed	,,	0	4	6	
112	,, ,, ,, superior	,,	0	5	0	
113	,, ,, of movable venetians	,,	0	12	0	
114	,, ,, fixed ,,	,,	0	6	0	
115	Wooden cornice for wall cupboard or picture rails (simple design)	rft.	0	2	6	
116	Wooden ceiling with butt joints	% sft.	8	8	0	
117	,, tongued and grooved	,,	6	0	0	

Item No	Description	Unit	Rate Rs	a	p	Remarks
118	Collar beam truss up to 12 ft span	each	8	0	0	
119	King post truss up to 20 ft „	„	6	0	0	
120	„ „ „ 30 ft „	„	8	0	0	
121	Queen post „ „ 30 ft „	„	10	0	0	
122	Fixing c i sheet roof including purlins, eaves and barge-boards	% sft	4	8	0	
123	„ „ Mangalore pattern tiled roof	„	6	8	0	
124	„ „ Country tiled „	„	10	0	0	
125	Planing and fixing eaves & barge-boards plane	rft	0	1	0	
126	„ „ ornamental pierced work	„	0	8	0	
127	Laying ridge tiles in cement	„	0	0	9	
128	Staircase wooden plain 2 to 4′ wide	step	1	8	0	
129	„ „ „ spiral	„	5	0	0	
130	Railing of square battens simple design 3′ high	sft	0	2	0	
131	„ „ turned balusters	„	0	8	0	
	R. C. C. CENTERING					
132	Fixing centering for slab	% sft	2	8	0	
133	„ „ circular column upto 15″ diam.	sft.	0	1	0	
134	„ „ square „ „	„	0	0	6	
135	„ „ lintels, beams and walls	„	0	0	6	
136	„ „ below overhanging chhajjah or gallery	„	0	0	9	
137	„ „ staircase straight	„	0	0	6	
138	„ „ „ special	step	0	8	0	
	WHITE AND COLOUR WASHING, PAINTING, ETC.					
139	White-washing three coats on new work	% sft	0	4	0	
140	„ „ two coats on old work	„	0	2	0	
141	Colour-washing three coats new work	„	0	6	0	
142	„ „ two coats on old work	„	0	4	0	
143	Distempering walls with a priming coat of white-wash	„	0	8	0	
144	Priming coat of oiling or sizing	„	0	4	0	
145	Painting two coats on priming coat	„	0	8	0	
146	Scraping old paint, scrubbing priming and two coats of oil paint	„	1	0	0	
147	Coal tarring one coat	„	0	6	0	
148	„ „ two coats	„	0	8	0	
	PLUMBING WORK					
149	Laying 6″ stone ware pipe including excavation, jointing pipes to proper grade in cement with gasket and refilling trench	rft	0	4	0	
150	„ „ 4″ S W pipe drain	„	0	8	0	
151	Constructing gully trap inspection chamber 9″ ×12″	each	1	0	0	
152	„ „ 12″ ×18″	„	8	0	0	
153	„ „ 1½′ × 2′	„	5	0	0	
154	„ „ 1½′ × 3′	„	6	0	0	
155	„ „ 2′ × 3′	„	8	0	0	
156	Fitting Indian type W. C. pan	„	8	0	0	
157	„ „ with lead pipe and 3 gallon flushing tank	„	8	0	0	

Item No	Description	Unit	Rate Rs	a	p.	Remarks
158	Fitting European type W C Pan	each	10	0	0	
159	Fitting a lavatory basin with hot and cold taps lead trap etc	,,	4	0	0	
160	,, ,, glazed china urinal ,,	,,	8	0	0	
161	,, Nhani trap including cutting concrete floor	,,	0	12	0	
162	,, ,, 3" cast iron rain water or vent pipe with all fittings	rft	0	2	0	
163	Fitting 4" soil pipe including jointing, with all fittings	,,	0	3	0	
164	Fitting cast iron bath tub complete with hot and cold taps complete	each	8	0	0	
165	Making water connections with all fittings of ½ inch g i pipe	rft.	0	0	6	
166	,, ¾ ,, ,,	,,	0	0	9	
167	,, ,, 1 ,, ,,	,,	0	1	0	
168	Fitting one inch hand pump complete	each	2	8	0	
169	Cutting hole in a wall or floor for a plumbing connection and refilling it including finishing	,,	1	0	0	
170	Fitting frameless mirror on wall in toilet room	,,	1	8	0	
171	,, ,, glass towel rail	,,	1	0	0	
172	, ,, soap holder	,	0	8	0	
173	,, ,, toilet paper holder	,,	0	8	0	
174	,, ,, coat hanger	,,	0	4	0	

APPENDIX III

STANDARD METHOD OF TAKING MEASUREMENTS.

Materials

Stone Rubble—is stacked in rectangular heaps and from the cubic contents obtained by multiplying length, breadth and the mean of heights taken at two or three places, 10% is deducted for the voids

Khandkees are placed in rows with the faces in a line and running measurements are taken by a tape A better way would be to take the measurements when they are fixed in masonry as this would eliminate bad khandkees automatically Mention to this effect should be made in the agreement made with the supplier. It would pay in the long run even if 2 or 3% extra rate has to be paid for this

Headers and *small corner* stones upto 8" height are measured and paid for per 100 numbers Face measurements in square ft. on the exposed faces are taken of larger corners and paid for at a rate based on superficial ft

Stones for *String Course* are measured on running ft

Bricks and *Tiles* are paid at a rate per thousand

Flagstones are measured and paid for at a rate per hundred square ft

Slaked lime is paid for per hundred cub. ft But sometimes it is paid for per maund on private works 115 mds.=100 cub. ft

Stone-ware pipes which are in 2 ft. lengths are sold per number; so also all the fittings for plumbing either of stone-ware or cast iron Ordinary cast iron and soil pipes are each six ft. long and are sold per pipe and their pieces at per ft length

Measurements of work

Excavation for foundations. The measurements must be either the exact lengths, breadths and depths according to the drawings, or the architect's or supervisor's instructions If either for convenience of work or through negligence of the contractor extra widths or depths are excavated, they are not to be paid for The rate includes the cost of shoring to keep the sides from falling and also for carrying the materials to a distance within 50 ft. from the centre of the excavation, and neatly stacking it there The

excavation may fall in either of the seven different classes, *viz.*, earth or sand which includes all earthy or clayey material such as gravel, silt, clay, etc, soft murum, hard murum, hard murum and boulders, soft rock, hard rock blasted, or hard rock wedged and chiselled. These are measured and paid for at separate rates (*vide* appendix)

For measuring the quantity of *concrete*, the depth below the ground evel, up to the top of the concrete should be measured and deducted from the total depth of the excavation

The *masonry under ground* is measured just like concrete.

If finely dressed stone is used for stones in the face work of the plinth, the dressing is measured in square ft. and paid for separately on private works In the P. W D. a through rate which includes dressing, is given

Corners are included in the masonry and are not separately paid for. Dressing of small corners up to 8" in height is included in the rate of masonry, but on private jobs corners bigger than 9" in height if finely dressed, the dressing is separately paid for The measurements are taken on the exposed faces Similarly the labour for dressing of string course, arch stones. cut-stone steps, is separately paid for

For the length, a measurement along the centre line of walls is taken and is multiplied by the width and height. Deduction is made for window and door openings for which the clear opening inside the frame is measured

The measurement of *cupboard* space for deduction from the contents of walls depends on the mutual understanding; if they are only a few they are not deducted

Brick walls 9 or 10 inches wide are measured in cub. ft. in the P. W D., but on private works superficial measurements are taken on one side Walls of half brick thickness and under are always measured in superficial ft

Doors and windows are paid for the measurement *inside the frame* The rate per sq ft. includes the frame though it is not included in the measurements

Lintels and *flat arches* are measured in cft.

For *arches* the length is measured along the centre line of the arch ring and when multiplied by the thickness of the arch ring and the width of the wall, gives the cubic contents. The rate is per 100 cft

No separate measurement of relieving arches is taken since they do not require any centering. At the most four to eight annas per relieving arch are given extra depending upon the length of the arch

Plaster work is measured in sq. ft. area. If it be only on one side no deduction for door or window opening is made If it be on both sides then deduction from one side measurements is made

The same thing applies to painting In measuring painter's work on doors, windows, venetians, louvres, trellis work, etc., no deductions are made for glass work or the spaces not painted

R.C.C. slab is measured in sq. ft. The portion going into the walls is also measured. The rate includes finishing also from below. Beams and columns are measured in cft

The measurements of cupboards are taken just like those of doors. The rate includes the frame and shelves.

Roof is measured in sq. ft., *i.e.*, the length of the ridge multiplied by the sloping width from the ridge to the eaves.

Wood work of roofs such as that for trusses, purlins, ridge, wall plates, rafters, etc., is measured separately in cft. The eaves and barge-boards are also separately measured.

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